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On the cover: Wolf-eel, *Anarrhichthys ocellatus*, and starfish photographed off Mukilteo, Wash., by Ben Patten, Northwest and Alaska Fisheries Center, NMFS, NOAA, Seattle, Wash.

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Value Added, Margins, and Consumer Expenditures for Edible Fishery Products in the United States, 1976-78

ERWIN S. PENN and WENONA J. CREWS

Introduction

Sales and consumption of fish can be expressed in quantity or value. However, to add the round weight quantities of different types of fishery products (fish and shellfish) is not recommended. It would be like adding quantities of apples and oranges. The result would not make much economic sense for certain comparisons and calculations. To express sales and consumption in value terms, which is the purpose of this study, would be more meaningful when comparisons are made with gross national product (GNP) and total food consumption.

This study develops estimates of margins and value added for all fisheries at every level of production and marketing and also the consumer expenditures for all fishery products from the sea. From these estimates can be derived other values and information, such as the percentage of personal income spent on fishery products, per capita expenditures for fish, fisherman's share of the consumer dollar for fish, in addition to the food fish share of total food consumption and contribution of the U.S. fishing industry from different levels of production and marketing to GNP.

Each year, beginning with the 1978 issue, a table presenting margins, value added, and consumer expenditures for fishery products (similar to Table 1) will appear in the "Fisheries of the United States," published by the National Marine Fisheries Service (NMFS), NOAA. Since that publication is a statistical report, no detailed discussion about the table is presented. This article was prepared to present such a discussion so that users of the table will be better able to interpret the meaning and use of the information contained therein.

Data used in the analysis of this study are from various sources. Price data at the harvesting, processing, wholesale, and retail levels are principally collected by NMFS and appear in various publications. Data on costs and earnings of fishing vessels and processing plants are drawn from information provided by various government and private agencies. Appendix A describes source materials.

Definition and Relationship of Terms

The terms used in this analysis and their relationship require some definition and clarification. Margins, value added, and consumer expenditures are interrelated. Value added is part of the operating costs interpreted as the margin between selling and purchase values at either a production or a marketing level. The sum of margins at different production and marketing levels and harvesting costs, after deducting the export value, is the total consumer expenditures for fishery products. To calculate these values one has to start from the actual production or sales value and the cost of purchases (or purchase value) at the production levels. For fisheries, production has two levels, harvesting and processing; and distribution has four levels; wholesale, retail, public eating places, and institutions that serve food.

The difference between the sales value (V_s) and the purchase value (V_p) is the "margin" (M). There is no margin value, however, that can be realized at the harvesting level, because fishermen catch their fish without paying any purchase price. At the harvesting level, fishermen incur what is termed the "harvesting bill," which includes fishing costs, taxes, and profit or loss. From the purchase values and margin information at other levels, a factor called the "markup rate" (R_m) is derived that is used in this study at every step of the calculation.

The selling price at the harvesting level is the purchase price paid by processors. The purchase price at the wholesale level is the selling price quoted by processors, etc. A markup

ABSTRACT–The presentation in value terms of the basic estimates in this study makes it possible to produce analogous figures that can be compared with gross national product value of other industries, and total and per capita expenditures for other food products.

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Table 1.—Value added, margins, and consumer expenditures for edible fishery products in the United States, 1976-78.

Value	Domestic		Imports[1]		Total margin	Value-added rate[2] (%)	Value added[3] (contribution to the economy as GNP)	
	Sales	Margin	Sales	Margin			Total ($ million)	Percentage of total
	Million dollars							
1976								
Domestic landings	1,353	—	—	—	—	—	—	—
Industrial fish[4]	− 89	—	—	—	—	—	—	—
Edible fish (harvesting bill)	1,264	—	—	—	1,264	66.07	835	16.43
Exports (unprocessed)[5]	− 64	—	—	—	—	—	—	—
Total domestic sales	1,200	1,200	—	—	—	—	—	—
Imports	—	—	1,917	1,917	—	—	—	—
To be processed	—	—	484	—	—	—	—	—
To trade dealers	—	—	1,433	—	—	—	—	—
Processing level[6]	2,535	1,335	799	315	1,650	61.80	1,020	20.07
Exports (processed)[7]	238	—	—	—	—	—	—	—
Domestic sales	2,297	—	—	—	—	—	—	—
Wholesale level[8]	2,735	437	2,592	360	797	61.70	492	9.68
Channels to consumers								
Retail stores[9]	1,294	282	1,657	362	644	79.20	510	10.03
Public eating places[10]	3,569	1,983	2,566	1,425	3,408	62.29	2,123	41.76
Institutions[11]	228	92	260	104	196	52.50	103	2.03
Consumer expenditures[12]								
Sales through three channels	5,091	—	4,483	—	—	—	—	—
Landings (or imports) plus margins at five levels minus exports	—	5,091	—	4,483	—	—	—	—
Fisherman's share of a consumer's dollar for fish	—	(23.6%)	—	—	—	—	—	—
Total consumer expenditures	(53.2%)		9,574	(46.8%)	—	—	—	—
Total value added (contribution to the economy as GNP)	—	—	—	—	—	—	5,083	100.00
1977								
Domestic landings	1,515	—	—	—	—	—	—	—
Industrial fish[4]	−111	—	—	—	—	—	—	—
Edible fish (harvesting bill)	1,404	—	—	—	1,404	67.66	950	17.09
Exports (unprocessed)[5]	−107	—	—	—	—	—	—	—
Total domestic sales	1,297	1,297	—	—	—	—	—	—
Imports	—	—	2,078	2,078	—	—	—	—
To be processed	—	—	567	—	—	—	—	—
To trade dealers	—	—	1,511	—	—	—	—	—
Processing level[6]	2,781	1,484	920	353	1,837	62.23	1,143	20.57
Exports (processed)[7]	319	—	—	—	—	—	—	—
Domestic sales	2,462	—	—	—	—	—	—	—
Wholesale level[8]	2,971	509	2,841	409	918	62.85	577	10.38
Channels to consumers								
Retail stores[9]	1,410	329	1,815	424	753	80.21	604	10.87
Public eating places[10]	3,782	2,041	2,776	1,498	3,539	61.49	2,176	39.15
Institutions[11]	245	96	281	110	206	52.50	108	1.94
Consumer expenditures[12]								
Sales through three channels	5,437	—	4,872	—	—	—	—	—
Landings (or imports) plus margins at five levels minus exports	—	5,437	—	4,872	—	—	—	—
Fisherman's share of a consumer's dollar for fish	—	(23.9%)	—	—	—	—	—	—
Total consumer expenditures	(52.7%)		10,309	(47.3%)	—	—	—	—
Total value added (contribution to the economy as GNP)	—	—	—	—	—	—	5,558	100.00
1978								
Domestic landings	1,854	—	—	—	—	—	—	—
Industrial fish[4]	−121	—	—	—	—	—	—	—
Edible fish (harvesting bill)	1,733	—	—	—	1,733	68.40	1,185	18.58
Exports (unprocessed)[5]	−221	—	—	—	—	—	—	—
Total domestic sales	1,512	1,512	—	—	—	—	—	—
Imports	—	—	2,275	2,275	—	—	—	—
To be processed	—	—	677	—	—	—	—	—
To trade dealers	—	—	1,598	—	—	—	—	—

Table 1.—Continued

Value	Domestic		Imports[1]		Total margin	Value-added rate[2] (%)	Value added[3] (contribution to the economy as GNP)	
	Sales	Margin	Sales	Margin			Total ($ million)	Percentage of total
	Million dollars							
Processing level[6]	3,215	1,703	1,116	440	2,143	62.70	1,344	21.07
Exports (processed)[7]	514	—	—	—	—	—	—	—
Domestic sales	2,701	—	—	—	—	—	—	—
Wholesale level[8]	3,263	561	3,170	455	1,016	63.65	647	10.14
Channels to consumers								
Retail stores[9]	1,595	356	2,040	455	811	81.10	658	10.32
Public eating places[10]	4,129	2,269	3,096	1,701	3,970	61.00	2,422	37.98
Institutions[11]	270	107	315	125	232	52.40	122	1.91
Consumer expenditures[12]								
Sales through three channels	5,994	—	5,451	—	—	—	—	—
Landings (or imports) plus margins at five levels minus exports	—	5,994	—	5,451	—	—	—	—
Fisherman's share of a consumer's dollar for fish	—	(25.2 %)	—	—	—	—	—	—
Total consumer expenditures	(52.4%)		11,445	(47.6%)	—	—	—	—
Total value added (contribution to the economy as GNP)	—	—	—	—	—	—	6,378	100.00

[1]For imported fishery products, the margin and sales values at different levels are calculated in the same manner as they are for the domestic production column, except that the markup rate at the processor level is 0.6515 in 1976, 0.6232 in 1977, and 0.6495 in 1978; at the wholesale level the markup rate is 0.1612 in 1976, 0.1681 in 1977, and 0.1678 in 1978. The distribution rate is 50 percent in 1976, 49 percent in 1977, and 50 percent in 1978 at retail stores; 44 percent in 1976, 45 percent in 1977, and 44 percent in 1978 at eating places; and 6 percent at institutions in 1976, 1977, and 1978.
[2]Value-added rate at each level is the weighted average of all fishery products, expressed as a percentage of its corresponding margin.
[3]Multiply each item under the total margin column by its corresponding value under the value-added rate column to get the actual value added as contribution to the economy from all production and distribution levels of the U.S. fishing industry in the food fish sector.
[4]Value of landings of fish for industrial purposes is deducted.
[5]Exports of unprocessed fish are deducted from the value of the landings after being converted to an equivalent value for domestic landings.
[6]Processor's purchase value (or domestic sales at the harvesting level) times the processor's markup rate (weighted average for all fishery products is 1.1128 in 1976, 1.1447 in 1977, and 1.1262 in 1978) equals the margin at the processor's level.
[7]Exports of processed products are deducted at their export value from this level.
[8]Wholesale purchase value (processors' domestic sales) times the weighted average of markup rates (0.1904 for 1976, 0.2068 for 1977, and 0.2080 for 1978).
[9]37.0 percent of wholesale sales value is distributed in 1976 to retailers, 36.4 percent in 1977, and 38.0 percent in 1978. This value times the weighted average of markup rates (0.2790 in 1976, 0.3043 in 1977, and 0.2870 in 1978) at the retail level equals the margin at retail.
[10]58.0 percent of wholesale sales value is distributed in 1976 to eating places, 58.6 percent in 1977, and 57.0 percent in 1978. The margin and sales value at this level are obtained at a markup rate of 1.2499 for 1976, 1.1720 for 1977, and 1.2200 for 1978.
[11]A wholesale sales value of 5.0 percent is distributed to institutions with a markup rate of 0.6699 in 1976, 0.6472 in 1977, and 0.6550 in 1978; the margin and sales value at this level are then calculated.
[12]Consumer expenditures are the total sales value at retail stores, eating places, and institutions. This total is also the sum of margins of five marketing levels and the landings value after export value is deducted.
Note: The procedure for calculating the data in this table is based on two comprehensive reports, "Cost Analyses of U.S. Fish Price Margins, 1972-1977, at Different Production and Distribution Levels" and "Marketing Bill of U.S. Fish-Food Products", both prepared by E. S. Penn.

rate is the percentage increase over the purchase price to cover operating costs and profit to arrive at a selling price acceptable to the current market. If $R_m = 0.34$, it means that the margin is 34 percent of, and the selling price is 34 percent above, the purchase price.

The relationship of all the above-mentioned variables can be expressed as follows:

$$P_s \times Q_s = V_s$$

where P_s = selling price and
Q_s = selling quantity.

Also

$$V_s - V_p = M, \qquad M/V_p = R_m,$$
$$R_m \times V_p = M.$$
$$\therefore V_s = (R_m \times V_p) + V_p$$
$$= V_p\,(1 + R_m).$$

From the margin, a component called "value added" is derived. It has special characteristics. Value added is that part of the margin that excludes costs of materials, supplies, and services purchased, but includes payments to various production factors. For example, "wages and salaries" are paid to labor; "rent," for the use of land and building; "interest," for borrowed capital; "depreciation," to write off current wear and tear of machines and equipment; "profit," to management; and "taxes," to government. The total of these payments represents the contribution of an industry to the economy known as value added of the industry, while the cost of materials, supplies, and services are contributions to the economy from other industries. The latter group of costs is a value not added by, but transferred to, the industry in question (Buzzell, 1959). Each fishery has a value added different from

that of another. Each production or marketing level has a value added different from that of another level. The range of difference depends on how much is spent on each of the above-mentioned payments in relation to other costs. These payments (less taxes and depreciation), after they are injected into the cash flow of the economy, tend to generate income in other sectors of the economy and cause a multiplier effect. Payments under the value-added category, therefore, have a unique function distinguishable from other costs. The total value added of different fisheries at one production or marketing level is the fishing industry's contribution from that level to the national economy incorporated as part of GNP[1].

Value added at one level of the fishery can be expressed as a percentage of the margin of that level and is then called the value-added rate of the fishery at that level. It changes from year to year. A weighted average of value-added rates for all fishery products at each level is calculated for the period 1972-77 and projected to 1982 for this study.

Procedures of Calculation

To arrive at a net sales value at the harvesting level for domestic fish consumption, the catch of industrial fish and exports of unprocessed fish should be deducted from the total landings value. Some of the landings may be sold directly to consumers. They are mostly not reported as landings in the first place. We do not attempt to make any adjustment of this kind here, because the quantity involved is negligible compared with total landings and would not affect the total value added we intend to calculate.

What is landed is sold either to processors or other dealers. If the fish are sold to dealers other than processors, some processing work like cleaning, eviscerating, heading, sorting, and packing would be carried out before the fish are sold to consumers. In this case, some processing costs are added to increase the product value regardless of whether the processor does the work. As the end users, consumers would eventually bear these added costs. They should be classified as processing costs according to the function performed and allocated to the processing level as part of its value added, although workers at some other levels have done the job in its behalf.

All landings for domestic consumption are theoretically assumed to go through the processing level. Therefore, the processors' annual purchase value will be the domestic sales value at dockside for the same year. By the same token, the annual purchase value of wholesalers will be the annual sales value of the processors assuming that beginning and ending inventories at both levels would cancel each other.

The processors' sales value is calculated from the weighted average of markup rates of different fishery products at that level. The difference of their sales value and the purchase value paid to fishermen is the marketing bill of the processors. For the sake of convenience, "marketing bill" is shortened to "margin" from now on.

In the same manner, the weighted average of markup rates of wholesalers for different fishery products is applied to the wholesale level to get the margin and the sales value at this level. Not all fishery products are distributed to retailers and public eating places by wholesalers. Wholesale prices of canned tuna, canned salmon, and some canned shrimp are reported by cannery representatives or quoted as FOB canner's terminal. In this instance, canners are themselves wholesalers at the same time. A combined level called the processor/wholesaler level is created.

In this study, we break the combined level into two separate levels according to their functions by taking a fraction of the margin from canners and allocating it to the wholesale level. In this manner the canner/wholesaler level is eliminated on paper for the convenience of our level-by-level calculation. The combined operation of processing and wholesaling functions is encouraged, however, in that the net markup rate would be lower than if the two functions are operated separately.

From wholesalers, fishery products are distributed to consumers through three channels: Retail stores, public eating places, and institutions that serve food as a secondary function. Examples of the last channel include hospitals, military bases, prisons, school lunches, and train and airline food catering. Quantites and values of fishery products distributed through the three outlets change during different phases of the business cycle from recession to prosperity and vice versa. Consumers are likely to eat more at home in recession years than in prosperity years. Different products are disposed of in different proportions from three outlets in the consumer market. For example, more canned and frozen products are sold by retailers, whereas more shellfish and fresh fish are handled by eating places. In this study, a distribution pattern is established for each form of fishery product from a detailed survey of the U.S. food service industry published by the U.S. Department of Agriculture (1973). A weighted average of the ratios of distribution for all forms of products through each distribution outlet is estimated in each phase of the business cycle. Composition of domestic and imported fishery products is different, and, therefore, they assume different distribution patterns and ratios.

After different distribution ratios are applied to their corresponding outlets, purchase values are estimated for the three outlets. Margins and sales value are calculated when the markup rate for each outlet is provided. The total sales by the three outlets in the consumer market constitute the consumer expenditures for domestic fishery products ($5.99 billion in 1978). The same result is obtained by adding the margins of five marketing levels to the landing value after deducting exports (Table 1).

From imports, the semiprocessed and raw products are shipped to processors for reprocessing, whereas processed products (mostly frozen and canned) are distributed to trade channels. The sales and margin values are calculated in a similar manner as they

[1]Another method to calculate GNP is the flow-of-product approach. The value-added approach that is applied here is based on the flow-of-cost of production factors (Samuelson, 1976).

are done for domestic products, except that markup rates and ratios of the distribution pattern are not the same. Appendix Tables 2, 3, and 6 give these rates and ratios. Consumers' expenditures for imported fishery products were $5.45 billion in 1978.

A value-added rate is calculated for each major fishery product at each level from harvesting to public eating places for each year. For the purpose of this study, a weighted average of value-added rates of all fishery products at each level is calculated for each year from 1972 to 1977 and projected to 1982 (Appendix Table 4).

Multiplying the harvesting bill at the harvesting level and the margins of domestic and imported products at five marketing levels by their corresponding value-added rates will give an estimate of value added for each of the six levels in dollar terms. The total value added of the six levels is the contribution of the U.S. fishing industry from the food fish sector to the national economy in terms of GNP. In 1978, this sector contributed $6.38 billion as GNP to the national economy.

Consumer Expenditures for Seafoods

Estimates have been made to determine what percent of edible fishery products in the United States was imported. According to annual statistical data on the U.S. supply (landings and imports), imports were 56-60 percent by value and 61-63 percent by quantity (round weight) in 1976-78. Statistics in earlier years show that the percentage of imports was even higher. The assertion that over 60 percent of fishery products in the U.S. market is imported appears misleading, because the method of its estimation is too simplistic. Fish and shellfish are not identical in form nor equivalent in weight. They cannot be added by quantity in round weight. Because domestic landings and imported products differ in their proportions of fish and shellfish, the total round weight of one group cannot be compared with that of the other. The two groups of products are not equivalent in value either, because imports are mostly processed before entering the United States and priced higher than domestic landings yet to be processed.

The measurement that can produce more meaningful results for comparison purposes between domestic landings and imports is one to be made in value terms at the consumer market level. At this level, consumers, as final users, pay for the domestic and imported products that are all processed to the final desirable degree to meet the demand of consumers. Measured at this level, imported fishery products are found to be only 47.6 percent of the total sales value in 1978, 46.8 percent in 1976, and 47.3 percent in 1977, according to this study (Table 2).

U.S. consumers spent $11.45 billion on domestic and imported edible fish or $52.50 per capita in 1978. This was an increase in both total value and quantity from 1976 and 1977. Of the total expenditures for fish, consumers spend considerably more in public eating places than they do at home. According to the findings of this study, 68-70 percent of a consumer's seafood dollar is spent away from home (Table 2).

Disposable personal income (DPI) is the net amount of income per year available for private individuals and families to spend after depreciation and taxes are deducted from the gross national income (see Table 5). About 19.06 percent of DPI was spent on all foods in 1976 (Table 3). This rate dropped to 18.82 percent in 1977 and to 18.55 percent in 1978. Consumers spent only 0.8 percent of DPI on fish food in the last 3 years. Compared with 0.6 percent in 1974 and 0.73 percent in 1975 (Penn[2]), spending on fish consumption has been rising although the amount is insignificant compared with

[2]Penn, E. S. 1979. Marketing bill of U.S. fishfood products, 1972-77. National Marine Fisheries Service office document, 49 p. Office of Policy and Planning, National Marine Fisheries Service, NOAA, Washington, DC 20235.

Table 2.—Sales of domestic and imported fish products at the consumer market level, 1976-78.

Item	1976				1977				1978			
	Domestic	Imports	Total	Percentage of total	Domestic	Imports	Total	Percentage of total	Domestic	Imports	Total	Percentage of total
	Million dollars				*Million dollars*				*Million dollars*			
Retail	1,294	1,657	2,951	30.8	1,410	1,815	3,225	31.3	1,595	2,040	3,635	31.8
Public eating places	3,569	2,566	6,135	64.1	3,782	2,776	6,558	63.6	4,129	3,096	7,225	63.1
Institutions	228	260	488	5.1	245	281	526	5.1	270	315	585	5.1
Total	5,091	4,483	9,574	100.0	5,437	4,872	10,309	100.0	5,994	5,451	11,445	100.0
Percentage of total	53.2	46.8	100.0		52.7	47.3	100.0		52.4	47.6	100.0	
Per capita consumption												
Value (dollars)		44.59				47.66				52.50		
Quantity (pounds, edible weight)		13.0				12.0				13.4		
Resident population July 1 (million)		214.7				216.3				218.0		
Exports (million dollars)		329.8				473.4				831.7		

expenditures for meat or dairy products.

A direct comparison with total food consumption shows that fish consumption's share increased from 4.20 percent in 1977 to 4.25 percent in 1978. As a result of a more rapid increase in fish prices coupled with a steady increase in total quantity sold, fish consumption has gained some ground from other foodstuffs in competing for the consumer's food dollar in 1978 (Table 3).

Contribution to the National Economy

Every industry, manufacturing or service, has its contribution to the economy expressed as a part of GNP and derived from value added by all levels of activities from extraction through distribution. For fisheries, each of the six levels from harvesting to eating places has contributed to GNP in various amounts.

Table 3.—Seafood's share of total food expenditures and disposable personal income in the United States, 1976-78.

Year	Fish consumption ($ billion)	Total food consumption[1] ($ billion)	Fish consumption as percentage of total food consumption	Disposable personal income (DPI)[1] ($ billion)	Fish consumption as percentage of DPI	Total food consumption as percentage of DPI
1976	9.57	225.80	4.23	1,184.40	0.81	19.06
1977	10.31	245.20	4.20	1,303.00	0.79	18.82
1978	11.45	269.20	4.25	1,451.20	0.79	18.55

[1]U.S. Department of Commerce, Bureau of Economic Analysis.

Table 4.—Contribution to GNP by the U.S. fishing industry compared with selected major industry groups, 1976-78.

	At the harvesting level			At the processing level			At all levels from production to consumption				
		Fisheries			Fishery products		(A)	(B)	Fishery products		
Year	Agriculture, forestry, and fisheries	Contribution	Percentage of group total	Nondurable goods	Contribution	Percentage of group total	All industries	Food products	Contribution	Percentage of (A)	(B)
	Billion dollars			Billion dollars			Billion dollars				
1976	48.20	0.84	1.74	167.2	1.02	0.61	1,700.1	225.8	5.08	0.30	2.25
1977	54.20	0.95	1.75	186.2	1.14	0.61	1,887.2	245.2	5.56	0.29	2.27
1978	NA[1]	1.19	—	NA[1]	1.34	—	2,106.6	269.2	6.38	0.30	2.37

[1]NA=not available.
Source: Department of Commerce: Bureau of Economic Analysis and National Marine Fisheries Service.

Table 5.—Income generated for the national economy by the U.S. fishing industry, 1976-78, in millions of dollars.

Steps of calculation	1976	1977	1978
1. Value added (GNP)			
Less: Capital consumption	$5,083	$5,558	$6,378
(1976:10.64%; 1977:10.34%; 1978:10.30%)[1]	−541	−575	−657
2. Equals: Net national product (NNP)	4,542	4,983	5,721
Less: Indirect business taxes and transfer payments (1976:8.90%; 1977:8.95%; 1978:8.46%)[1]	−452	−497	−540
3. Equals: National income	4,090	4,486	5,181
Less: Corporate profit (1976:19.79%; 1977:20.13%; 1978:20.43%)[1]	−1,006	−1,119	−1,303
Plus: Government transfer payments, personal interest income, and dividend (1976:20.58%; 1977:20.35%; 1978:20.10%)[1]	+1,046	+1,131	+1,282
4. Equals: Personal income	4,130	4,498	5,160
Less: Personal taxes (1976:11.56%; 1977:11.98%; 1978:12.16%)[1]	−588	−666	−776
5. Equals: Disposable personal income	3,542	3,832	4,384
6. Times: Multiplier coefficient[1]	2.12	2.51	2.68
7. Equals: Generated income to the national economy	7,509	9,618	11,749
8. Ratio between value added and generated income	1:1.48	1:1.73	1:1.84

[1]Ratios and coefficients are derived from actual figures given in tables for GNP, national and personal income, savings and investment, and import and export values, prepared by the Bureau of Economic Analysis, U.S. Department of Commerce 1976-78. Ratios are expressed as percentages of value added for each year.

Comparisons of such contributions can be made between different levels of the fishing industry and between the total of all levels of the fishing industry and the total of another industry. Contribution to GNP by all levels of the U.S. fishing industry was $6.38 billion in 1978, 14.8 percent higher than in 1977 and 25.5 percent higher than in 1976. Its actual rate of increase was about the same as that of the total GNP for all industries, but faster than that of GNP from food products (last column of Table 4). At the harvesting level, the growth rate of GNP for fisheries was more or less on a par with that for the combined industry group of agriculture, fisheries, and forestry. At the processing level, fisheries' contribution to GNP is increasing at a slightly faster rate than the contribution of nondurable goods (first two columns of Table 4).

In 1978, as in earlier years, fish processors contributed more to the national economy in terms of GNP than fishermen and vessel owners, after imported raw products are added to the production lines of processing plants. At the consumer market level, the food service industry sold twice as much fish food as retailers did in 1978, and its contribution to GNP was almost four times greater. Similar rates are found at the two corresponding levels in the earlier 2 years. This is conceivable, because eating places handled greater volumes of fish and required more labor, capital, and management costs to prepare and serve cooked fish than retail stores needed to retail uncooked fish products (Table 1).

GNP created by an industry is only the initial contribution to the economy. After deducting taxes, profits, and depreciation from GNP, the net will be the disposable personal income, the spending of which will touch off a chain reaction to generate employment and income in other sectors of the economy several times over within a year. This generated income can be calculated from the personal income flow created by the fishing industry and the multiplier coefficient of the national economy as demonstrated in Table 5. The multiplier coefficient is the reciprocal of the sum of the marginal propensity to save and the marginal propensity to import (Kindleberger, 1958).

Out of a total value added (or GNP) of $6.38 billion created by the U.S. fishing industry in 1978, $4.38 billion is netted as the disposable personal income for those employed by the industry and $11.75 billion is generated at the end of the year as income to other sectors of the economy (Table 5). This generated income is 22.2 percent higher than in 1977 and 56.5 percent higher than in 1976. The high rate of increase is influenced by a higher multiplier coefficient value in 1978. The percentage of income saved and that spent on imports of all commodities, as leakages of income, were highest in 1976 and lowest in 1978 among the 3 years. The lower the percentage of leakages of income, the more it will enhance the factors that tend to induce investment. As a consequence, the higher multiplier coefficient in 1978 will generate a greater income in proportion to the initial contribution of value added (line 8, Table 5).

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Appendix A: Source of Data

The "markup" rate of a fishery product is simply calculated from its selling and purchase prices at a production or marketing level. The National Marine Fisheries Service collects prices at all levels from ex-vessel, processing, wholesale, to retail. Some retail prices are gathered by the Bureau of Labor Statistics and a few by marketing service offices of different State Government agencies as supplementary sources. Price margins and markup rates are calculated for each fishery product through price analysis at each level. In this study, we calculate and use the weighted average of all fishery products at each level.

In an aggregate study, it is the sales value (price × quantity) at each level that should be considered. The Resource Statistics Division of NMFS publishes annual sales of fishery products at the harvesting and processing levels; however, the current or annual sales from the outlets of retail stores, eating places, and institutions are nowhere to be found. Estimates of sales from the above outlets can be made, however, based on a comprehensive survey of sales of the U. S. food service establishments through the channels of retail stores, various public eating places, and institutions to consumers (U. S. Department of Agriculture, 1973). From this source of information, fishery products are grouped into fresh finfish, frozen finfish, canned fish, shrimp of various processed forms, and other shellfish. A distribution pattern of these groups of products from processors/wholesalers to different trade channels presented in ratios is established so that it can be applied in the calculation of sales for other years. These ratios differ from year to year as the composition of products to be sold varies annually. A study for the period 1972-77 (Penn, 1979) indicates that some cyclical movements took place between recession and prosperity years: Consumers ate less fish away-from-home during recession years and more during prosperity years.

Information on costs and earnings of

fishing vessels is relatively sparse. The NMFS economics staff and a few private institutes have made studies on cost and earnings. The data of earlier years are adjusted by composite cost indices compiled by the Economic Analysis Staff of NMFS to bring them up to date.

At processing and marketing levels (including wholesalers, retail stores, and public eating places), costs and earnings data related to fisheries or seafood are published by the "Census of Manufactures, Statistics of Income" by the Internal Revenue Service, "Supermarket Performance Statements" by the Supermarket Institute, and some related studies by the U.S. Department of Agriculture. An analysis of the above cost information produced an estimate of value added of each fishery at each level according to the concept of production factors' costs adopted also by the Bureau of Economic Analysis of the U.S. Department of Commerce.

The combined information from all the above sources provides us not only the sales and margin values in aggregate terms, but also value-added rates at each level for all fishery products. For this study the weighted averages of the above values are used.

The skeleton of this study and the trends of different rate changes are derived from two comprehensive reports: "Cost Analysis of U.S. Fish Price Margins, 1972-77, at Different Production and Distribution Levels" and "Marketing Bill of U.S. Fish Food Products," both prepared by E. S. Penn.

Appendix B: Tables of Different Rates and Ratios Used in Calculations

Following are tables of weighted average markup ratios and value-added rates of fishery products at different production and distribution levels, and tables of distribution patterns for trade channels in the handling of fishery products in the consumer market. Ratios presented in the distribution pattern tables are cyclical in trend; those in other tables are actual figures for 1972-77 and projected estimates for 1978-82.

Markup rates at processing and wholesale levels have been increasing faster than at other levels, because they involve more labor and fuel costs which increased at a faster rate than most other costs. The major outlay of wholesalers is for storage and trucking operations, which mainly involve labor and fuel costs.

Retail markup rates will increase only slightly, and those for public eating places and institutions will tend to drop gradually according to past trends. This drop is made possible by the rapid increase of fast food outlets and the simplification of services. Such a drop may be halted or reversed, if energy problems, especially the gas fuel supply, are not solved in the near future.

Value-added rates vary more or less in line with markup rates, except that the latter are more responsive to changes in the prices of fuel and other materials, whereas the former are affected more by wage rates.

Appendix Table 1.—Weighted average of markup rates of different fishery products at each production and distribution level of the U.S. fishing industry, 1972-77 (actual) and 1978-82 (projected).

Year	Processing[1]	Wholesale	Retail	Public eating places	Institutions
			Ratio[2]		
1972	1.0557	0.1868	0.3441	1.2512	0.6802
1973	0.9931	0.1669	0.3283	1.1900	0.6200
1974	1.0627	0.1771	0.3906	1.2787	0.6700
1975	0.9780	0.2073	0.3405	1.2600	0.6700
1976	1.1128	0.1904	0.2790	1.2499	0.6699
1977	1.1447	0.2068	0.3043	1.1720	0.6472
1978	1.1262	0.2080	0.2870	1.2200	0.6550
1979	1.1320	0.2087	0.2872	1.2100	0.6530
1980	1.1378	0.2095	0.2878	1.2000	0.7520
1981	1.1401	0.2100	0.2882	1.2000	0.6510
1982	1.1413	0.2108	0.2885	1.2000	0.6510

[1]Purchase value at the processing level is based on landed weight at dockside with no adjustment made on a product weight basis. The markup rate is about 2.8 times higher, on the average, than if both purchase and selling values are adjusted on the same weight basis.

[2]A ratio between the margin and the purchase value. A ratio of 0.3441 at the retail level means that the costs and earnings margin of the retailer is 34.41 percent of his purchase value of the fishery product and the sales value is 1.3341 times higher than the purchase value.

Appendix Table 2.—Weighted average of markup rates of imported fishery products at processing and wholesale levels, 1977.

Product	Markup rates		Imported value	
	Processing	Wholesale	Unprocessed	Processed
	Ratio		*Million dollars*	
Blocks and slabs (to sticks and portions)	0.4133	0.1245	291.7	—
Halibut (to steaks)	0.3238	0.1252	9.1	—
Salmon (to steaks)	0.1481	0.4116	10.8	—
Tuna (to canned products)	0.8941	0.0785	255.3	—
Weight average ratio	0.6232 (=353.32/566.9)	0.1044	566.9	1,511.6

Note: When the four domestically processed imported raw products are distributed to wholesalers together with more than 30 varieties of other imports of processed products, the markup rate at the wholesale level is not the overall weighted average of 0.2068 for all products in 1977 (see Appendix Table 1), but a weighted average between 0.2068 and 0.1044 (the markup rate for four imported products of the same year), or 0.1681 arrived at as follows: $(1{,}511.6 \times 0.2068) + (920.5 \times 0.1044) = 408.70$, $408.70/2{,}432 = 0.1681$. (This is the rate used in Table 1 in the text referred to in footnote 1.)

Appendix Table 3.—Projection of markup rates for four imported fishery products at processing and wholesale levels, 1978-82.

Level and product	1978	1979	1980	1981	1982
			Ratio[1]		
Processing					
Blocks and slabs (to sticks and portions)	0.4200	0.4240	0.4290	0.4330	0.4380
Halibut (to steaks)	0.3120	0.3310	0.3520	0.3580	0.3600
Salmon (to steaks)	0.1400	0.1480	0.1500	0.1510	0.1520
Tuna (to canned product)	0.9100	0.9160	0.9270	0.9360	0.9400
Wholesale					
Sticks and portions	0.1290	0.1300	0.1320	0.1360	0.1390
Halibut steaks	0.1258	0.1330	0.1400	0.1440	0.1460
Salmon steaks	0.4000	0.4320	0.4500	0.4550	0.4600
Canned tuna	0.0792	0.0797	0.0806	0.0814	0.0818

[1] Ratio between the margin and the purchase price.

Appendix Table 4.—Weighted average of value-added rates of fishery products, expressed as a percentage of the margin at each production and distribution level of the U.S. fishing industry, actual for 1972-77 and projected for 1978-82.

Year	Harvesting	Processing	Wholesale	Retail	Eating places	Institutions
			Percent			
1972	62.23	59.10	52.17	74.42	66.29	54.90
1973	63.99	60.00	55.57	75.70	66.62	55.11
1974	60.63	61.00	58.55	77.00	63.96	52.24
1975	53.18	61.40	60.55	78.10	63.29	51.96
1976	66.07	61.80	61.70	79.20	62.29	52.50
1977	67.66	62.23	62.85	80.21	61.49	52.50
1978	68.40	62.70	63.65	81.10	61.00	52.40
1979	69.20	63.20	64.45	81.80	60.90	52.40
1980	70.00	63.70	65.25	82.60	60.80	52.30
1981	70.50	64.20	66.05	83.40	60.75	52.20
1982	71.30	64.70	66.50	84.20	60.75	52.20

Appendix Table 5.—Distribution pattern of domestic fishery products in different periods.

Period	Retail stores	Eating places	Institutions
		Percent	
Recession years	39.7	55.3	5.0
Recovery years	38.0	57.0	5.0
Prosperity years	36.4	58.6	5.0

Appendix Table 6. — Distribution pattern of imported fishery products in different periods.

Period	Retail stores	Eating places	Institutions
		Percent	
Recession years	51	43	6
Recovery years	50	44	6
Prosperity years	49	45	6

Oyster Seed Hatcheries on the U.S. West Coast: An Overview

JERRY E. CLARK and R. DONALD LANGMO

Introduction

Oyster production in the United States has been diminishing for nearly 80 years. Natural disasters (including disease and predation), pollution, siltation, and land reclamation projects have all contributed to the decline. Present U.S. production is not even equal to what once came from the Chesapeake Bay alone.[1] Meanwhile, oyster imports have been increasing (Table 1).

Table 1.—United States oyster supplies, 1960-77, in millions of pounds.

	Oyster supplies			
Year	U.S.[1]	Imports[1]	Total	West coast[2]
1960	60.0	6.6	66.6	11.0
1961	62.3	7.3	69.6	10.2
1962	56.0	7.4	63.4	10.8
1963	58.4	8.9	67.3	9.8
1964	60.5	8.2	68.7	10.0
1965	54.7	9.0	63.7	9.2
1966	51.2	12.0	63.2	7.8
1967	60.0	17.7	77.7	7.7
1968	61.9	15.6	77.5	7.8
1969	52.2	16.6	68.8	7.0
1970	53.6	15.5	69.1	8.0
1971	57.9	9.7	67.6	8.1
1972	52.5	22.3	74.8	7.3
1973	48.6	18.5	67.1	6.4
1974	44.9	16.0	60.9	5.1
1975	53.2	12.4	65.6	5.9
1976	54.4	18.0	72.4	N.A.[3]
1977	46.0	22.8	68.8	N.A.[3]

[1]For 1960-1973, U.S. Department of Commerce (1974); for 1974-77, U.S. Department of Commerce (1976).
[2]Published and unpublished data from Department of Fish and Game, California; Department of Fisheries, Washington; Department of Fish and Wildlife, Oregon.
[3]Not available.

[1]At the turn of the century, nearly 80 million pounds of oysters were harvested from the Chesapeake Bay (Matthiessen, 1971). In 1975 the total U.S. landings of oysters were reported as 53.2 million pounds (U.S. Department of Commerce, 1976).

Though U.S. oyster industry problems have been substantial, interest in identifying and solving the problems has accelerated. One measure of this research effort lies in a partial 22-year (1948-72) bibliography (Joyce, 1972) devoted almost entirely to oysters. It cites 4,117 references that appear at an accelerated rate.

A limited, but important, portion of the total research effort outlined by Joyce (1972), concerns hatchery propagation of "oyster seed," a loosely defined term referring to juvenile oysters of various ages which oyster growers place in suitable habitat. Oyster seed production, which includes the spawning of adults and a relatively short free-swimming larval period, has been an undependable link in the natural reproductive cycle of oysters.

Formal research was begun over 100 years ago to attempt to spawn oysters under controlled conditions and to improve on the chances of survival of the larvae and juvenile oysters (Brooks, 1879). A result of this has been the establishment of a small number of commercial oyster hatcheries. This paper discusses the role of commercial oyster hatcheries on the U.S. west coast.

Oyster Seed

Oyster seed may be placed by the grower into oyster beds in place of, or in addition to, those spawned and occurring naturally. Initially, oyster growers did not need to seed their beds. During the summer, resident adult oysters would spawn and the eggs would hatch in the warm waters surrounding the beds. Then, after a fairly short free-swimming larval period, the oysters would set on shells in the beds. Many growers facilitated the natural setting process by spreading cleaned shells of previously harvested adults in the beds.

Reliance on natural spawning has declined over the years due to some combination of the physical destruction of suitable available growing areas, such as pollution of the oyster waters, which kills the delicate oyster larvae, and the practice of growing transplanted oysters in water too cold to induce spawning but warm enough to raise oysters. The inhibiting effect of cold water on spawning is especially prevalent on the U.S. west coast where the Pacific oyster, *Crassostrea gigas*, is cultured (Steele, 1964). The west coast industry was built and, to a large degree, is still dependent upon growers being able to purchase Pacific oyster seed to restock growing beds.

Seed is purchased in either the "cultch" or "cultchless" form. Seed on cultch consists of cleaned adult oyster shell (cultch material) to which several young oysters (spat), have become permanently attached. Cultchless seed are single young oysters, available from some hatcheries, which have either been removed from the surface of initial attachment, such as plastic sheets, or were originally set individually on small pieces of shell or other calcium carbonate material.

Prior to 1971 the west coast oyster industry was heavily dependent on shipments of oyster seed on cultch from Japan. Oyster seed is collected in Japan on oyster shell which is punched and strung on wire. Each wire is about 6 feet long and contains 100 or more pieces of shell. Ten such wires, known individually as ren, equal a case, containing between 13,000 and 20,000 spat.

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The rens are used to collect spat by being suspended in waters rich in oyster larvae during the spawning season. Then, carrying their load of set oysters, the wires are removed from the water, graded for spat count, packed in wooden crates, and shipped by boat to the United States. During transit the crates of cultch are periodically sprayed with seawater.

Since about 1971, substantial and more or less consistent additions to the supply of oyster seed have become available. This seed is caught by methods similar to the Japanese, but in west coast waters. Before 1971, natural spawning was quite irregular for the three natural spawning areas on the west coast: Dabob and Willapa Bays in Washington, and Pendrell Sound in British Columbia.

In 1971, after more than 20 years of very undependable west coast seed production, 33,000 cases of seed were collected from a natural spawn in Dabob Bay. In the previous year, for comparison, the total volume of seed planted in the entire State of Washington was only 27,000 cases, of which 22,000 were imported from Japan (Westley, 1976). Since 1971, there have been 4 years when more than 30,000 cases of seed have been collected in Dabob Bay: 1972, 1973, 1974, and 1977. There was a complete set failure at Dabob Bay in 1975 and 1976.

Hatchery Technique Developments

The current emphasis on hatchery techniques to produce oyster seed is motivated by the lack of a constant west coast source of seed and a threefold increase in the cost of Japanese seed between 1960 and 1975. Developing commercial hatchery methods to replace total reliance on natural sets has been at least a 100-year endeavor. The first report of successful artificial spawning of oysters was in 1879 (Brooks, 1879). Brooks was able to develop free-swimming oyster larvae from eggs and sperm stripped from adult female and male oysters during the normal spawning season.

All the steps in the hatchery process were not completed by Brooks because he was unable to rear the larvae he had hatched. Larval rearing remained the central hatchery problem for decades due to inadequate information on oyster diets. Two years after Brooks' work and in spite of a deficiency in nutritional information, M. Bouchen-Brandeley in France was able to spawn oysters, raise the larvae in large outdoor ponds, and finally set the larvae on collectors (Kellogg, 1910). Apparently, natural nutrients in the large ponds were sufficient for the larvae.

Following Brandeley, and during the early part of the 20th century, most research was directed toward improving the techniques of spawning and larval rearing. Experimentation with setting materials and techniques, is more recent.

Some of the most important research into the spawning characteristics of oysters was done by Victor L. Loosanoff (1937). Loosanoff's work was built, at least in part, on clam research done earlier by David Belding (1910) and Irving Field (1924). Belding and Field are most responsible for identifying and experimenting with the variables such as water temperature, salinity, and chemicals which affect time of spawning and degree of success. Loosanoff (1945) was the first to report successful experiments to induce spawning of oysters out of season. Loosanoff does acknowledge, however, that others, most notably D. L. McKernan and Vance Tarter, were simultaneously achieving the same results at the State of Washington oyster laboratory at Gig Harbor.

Some of the most important research leading to successful commercial development of oyster hatcheries relates to larval rearing. Not until 60 years after Brooks' work was definitive research done on the diet of oyster larvae. In England, Bruce et al. (1940) published the first results on oyster larvae growth rates associated with various algal diets. Their work was based on earlier studies in England during the 1930's by H. A. Cole (1937) on the European oyster, *Ostrea edulis*. It was not until 1953 that a similar study on larval diets was completed by Davis (1953) in the United States for the Virginia oyster, *Crassostrea virginica*. As stated, most research into the techniques and materials needed to set oyster larvae occurred rather recently.

Most accounts attribute the first development of "cultchless" oyster setting techniques to W. W. Budge in 1967, who was working for Pacific Mariculture[2] (Dupuy et al., 1977), a commercial oyster hatchery in California. However, one important development in setting techniques, occurring nearly a half century earlier is often overlooked. Most of those who have studied the history of oyster seed hatcheries attribute to W. F. Wells, working in 1920, the first successful spawning, rearing, and setting of oysters in confined jars and tanks in a laboratory. These three steps are essential to a complete hatchery. Previous successful larval rearing took place only in large outside ponds.

One important aspect of Wells' work appears to be overlooked. Wells (1920) set oysters on boards covered with a lime and sand mixture. As the set juvenile oysters grew, they crowded each other and began to turn up on edge and break loose from their attachments. Following separation from the boards the spat were raised in trays in seawater. The young spat were subsequently placed in growing beds upon attaining sufficient size, as single unattached oysters. Apparently Wells developed one of the earliest "cultchless" hatchery techniques, as well as providing the earliest example of the total hatchery concept.

Research effort and success over the past century are reflected in the practices of current commercial oyster seed hatcheries. The major steps for the several variations in hatchery practices are summarized in Figure 1. These steps applied in unison with knowledge about water quality and disease control have subsequently reduced the risks in propagating juvenile oysters or larvae.

[2]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

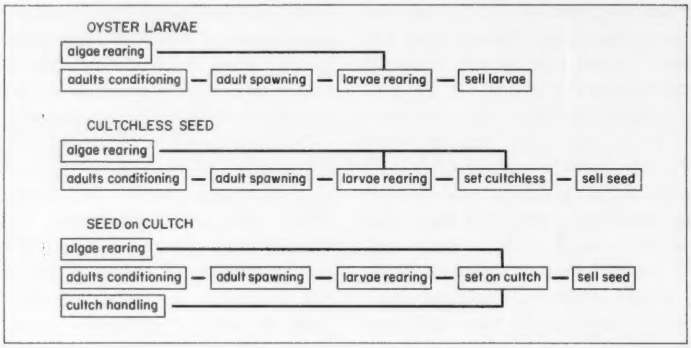

Figure 1.—Primary oyster hatchery operations for hatcheries producing larvae, cultchless seed, and seed on cultch.

Oyster Hatcheries: Problems and Potentials

The future of west coast oyster seed hatcheries depends on the interactions of several variables which, together, determine the market for oyster seed. The market for seed involves such elements as changing consumer demand for oyster products to water temperatures in the natural seed-propagating areas of Dabob Bay. This discussion identifies and considers the effects of changes in the major variables. The probable immediate future of west coast oyster hatcheries is briefly discussed.

The method used to identify market complexities faced by oyster hatcheries is based on the decision-making process of the oyster growing rather than the hatchery operator. The oyster grower makes two decisions which affect the oyster seed market: 1) Which mode of culture to use, and 2) where to get the desired type and quantity of seed. The process followed here captures only the major issues in the grower's decision-making process. As in other businesses, each member of the industry faces different circumstances, which makes each decision-making process unique.

Since the different oyster culture techniques involve the use of different forms and sizes of seed, the total size of any particular segment of the industry determines the demand for each form of seed. The following analysis of the different cultural techniques which employ both seed on cultch and cultchless seed indicates the forces affecting the demand for oyster seed.

Seed on Cultch

The choice of cultural technique for west coast oyster growers is and has been relatively easy. Here, bottom culture is traditional, beginning with seed on cultch spread evenly on or near intertidal lands from barges during high tide. During low tide, the previously spread seed is more evenly distributed by hand. Hand-transfer of seed, though declining, is used to thin overly-dense growing beds and to transfer oysters from seeding beds to fattening beds.

It takes from 2.5 to 4 years after planting before oysters are harvested when raised on the bottom. Most, however, are harvested after 3 years. Three harvesting methods are currently in use on the west coast. The first involves filling large baskets by hand during low tide and then at high tide locating the baskets by an attached marking buoy and loading the then submerged baskets by crane onto the oyster barge. The second method uses two dragline dredges mounted on each side of the oyster barge. Finally, and only recently introduced to the west coast industry, rather large hydraulic suction dredges are used to harvest and to transfer seed from bed to bed. Nearly the entire west coast production of oysters in 1975, 5,832,417 pounds, was produced with such techniques (Case 1976, Moos, 1975, and Oliphant[3]).

Since bottom culture, the predominant method, employs oyster seed on cultch, there is a sizable demand for such seed. A rough estimate of the quantity of seed on cultch demanded, based on west coast use during the past 10 years, runs about 50,000 cases per year. It is common for the total to be very much higher or lower during individual years. The estimate is an average, based primarily on statistics of total production and cases of seed planted, provided by the Washington State Department of Fisheries.[4]

The immediate future holds little promise that the total seed planted on cultch will significantly exceed 50,000 cases. In fact, since the 1950's, the total seed planted in the State of Washington has declined from an average of 53,000 cases to 39,000 cases per year during the first 6 years of the 1970's. However, since an increase in the amount of seed planted might be beneficial to oyster hatcheries, there is some merit in exploring ways such an increase could come about.

Several ways to increase total oyster production are based on techniques of production different from the traditional bottom culture. Many of the alternative culture methods do employ seed on cultch, however. A good synopsis of alternatives to bottom culture is presented by Bardach et al. (1972). In general, the use of stakes or suspending rens from rafts allows growers to generate greater production

[3]Oliphant, M. S., Associate Marine Biologist, Department of Fish and Game, California State Fisheries Laboratory, Long Beach, Calif., pers. commun., 1977.

[4]The seed planted in Oregon and California are estimates computed by dividing annual oyster production in each of those states by a conversion factor of 20 gallons of production per case of seed planted. The conversion factor is approximately the average return in the State of Washington between 1966 and 1975. If, for example, 1,000,000 pounds are harvested, and a gallon of oysters weighs approximately 8 pounds, then it can be estimated that 6,250 cases of seed were planted [(1,000,000 pounds)/(8 pounds/gallon)/(20 gallons/case)] to achieve that production.

by using the water column instead of the bottom alone.

So far, very little west coast oyster production is done with alternative techniques employing oyster seed on cultch. Two factors are mainly responsible for restricting movement into the alternative cultural techniques. The primary limiting factor is the belief of many growers that the cost of producing oysters by methods using stakes, racks, or rafts is greater than the increase in returns from increased production. The word "belief" is used because there are a few growers on the west coast successfully employing cultural techniques other than bottom culture.

The second limiting factor is both social and political. Intensive cultural methods involve placing structures such as stakes and racks on intertidal flats, or rafts or longlines in deep water. Stakes and racks employed in the intertidal areas are exposed during low tide, and can literally cover the bottom over large areas where oysters are cultivated in this form. The stakes and racks, in the eyes of many, are a form of visual pollution and may be vigorously opposed. Rafts and longlines used in deeper water, also have negative visual aspects and, depending on location, may be impediments to navigation. In view of these restraints, the movement into intensive cultural techniques, even if economically feasible, will develop slowly, if at all.

Cultchless Seed

Use of cultchless seed on the west coast is both limited and experimental. One Oregon grower rears cultchless seed in stacks of trays until it is large enough to be transferred to one of several layers in a wire cage where it remains with only periodic cleaning and thinning until harvest. This grower is only one of a handful on the west coast who has oyster ground which is not intertidal, and was successful in obtaining permits to place oyster-growing facilities in navigable waters. Expansion of this method of production is limited primarily by the same restraints as those experienced by nonbottom growers employing seed on cultch, discussed previously.

Cultchless seed is also being experimentally placed in intertidal oyster ground instead of the traditional seed on cultch. At present the practice looks uneconomic due to high mortality and, hence, low yield if small, less expensive seed is used, and too costly when larger, more expensive seed is used. The practice is not being ruled out, however, as only preliminary results are available.[5]

Finally, the relatively small size of cultchless seed (2-mm seed is sold) opens markets for cultchless seed which do not exist for the extremely bulky cultch type seed. Where 1 million spat would equal about 67 cases (167 bushels) of seed on cultch, the same amount of cultchless seed is equal to only about 1 liter (slightly more than 1 quart). Many millions of cultchless seed oysters can, and are, being sent throughout the world by hatcheries on the west coast. The market for cultchless oyster seed, while very small on the west coast, may prove significant worldwide. Also, if some of the experiments mentioned earlier are successful, a modest expansion of the present market for cultchless seed on the west coast could occur.

Two conclusions regarding the demand for oyster seed are apparent from the previous discussion. A significant demand exists for oyster seed and a significant increase in that demand is possible but not imminent. The likelihood of large increases in seed planted on the west coast each year is not great. As mentioned, significant change in local seed demanded is possible, but only if new production technologies, such as those which make use of the entire water column, are adopted.

There appear to be some good reasons why this development will be slow. First, most of the alternative technologies will be practical only if production costs can be reduced, a process that usually occurs rather slowly. However, the primary reason for expecting only modest growth is related to the sociopolitical issues. The use of the nation's estuaries is increasingly scrutinized. As various user groups compete, the process of altering the present uses becomes increasingly difficult.

Competing Seed Sources

The second major decision for a grower is where to buy seed. The question of a seed source (or sources) has become complicated, especially since 1971. At present, the west coast grower can choose among three potential seed sources: 1) Imported Japanese seed, 2) domestic and Canadian wild seed, and 3) hatchery seed.

Ideally, the grower would like to acquire seed solely on the basis of the greatest return per dollar spent. If the grower were able to make a decision, based simply on the cost per case of seed from each of the three sources, the task would be relatively simple. Such a calculation, however, is not easily accomplished. The fact that two cases of seed have the same spat count does not mean they will produce a similar amount of oysters, even when grown under the same conditions. Several factors contribute to variations in productivity.

One such consideration, for example, is the relative thickness of the underlying cultch material. Both wild seed and hatchery seed on the west coast are caught on local oyster shell, which are relatively thick and not easily broken. In contrast, Japanese seed is caught on a thinner shell, which can increase the amount of final production per case. The Japanese seed can be broken by hand, and sometimes even by crowding of the growing oysters on it. In either case, the breakable thin shell seems to lead to decreased mortality and, in turn, increased productivity.

Such differences in seed quality, regardless of the cause, complicates the grower's objective of maximum return per dollar spent on seed. Even if a decision can be made about which seed is preferred on the basis of quality, there is a further problem: availability of seed from each of the three sources may vary significantly.

[5]Breese, W. P., Associate Professor of Fisheries, Oregon State University, Corvallis, Oreg., pers. commun., 1977.

In 1971 nearly 30,000 cases of seed were collected in Dabob Bay, Wash. The following year, orders for Japanese seed in the State of Washington dropped from 25,486 cases to 7,321 cases. The same pattern existed for the next 5 years. In 1976, after 2 years with no wild seed, growers in Washington ordered large quantities of seed from Japan. Then in 1977 large quantities of wild seed were again collected in Dabob Bay. A near failure in Japan to collect seed in 1977, coupled with the large set in Dabob Bay, meant that in 1978 little or no seed was imported. Wide variation in the supply of wild seed has provided a difficult marketing environment for the planning and development of west coast hatcheries.

The first oyster seed hatchery was built on the west coast in 1967 with the hopes of being able to compete with Japanese seed which was rapidly increasing in price (between 1960 and 1975 the price tripled). Some seed was sold, but the hatchery eventually failed due to biological problems. (Since then the hatchery has reopened, successfully.)

During the 1970's other hatcheries were opened, but the total seed sold or produced by all hatcheries and used by growers on the west coast has never been very large. Early in the 1970's the consistent natural sets in Dabob Bay meant that hatchery seed had to compete with the relatively inexpensive wild seed as well as the more expensive Japanese seed. The hatcheries were basically unable to compete.

Finally, in 1975 and 1976 when there was, for practical purposes, no wild seed collected on the west coast, the growers, especially in Washington, turned to the hatcheries and requested they produce the tens of thousands of cases of seed the growers needed. The outcome was not unpredictable. After 4 years of being unable to sell seed due to the large natural sets, the remaining hatcheries simply were not in a position to produce so much in such a short time. Thus, orders were sent to Japan in 1976 for seed to be delivered in 1977.

Hatcheries have continued to exist on the west coast despite the problems (five are in commercial operation), but only one small hatchery of the five is strictly independent of other income sources, and sells seed to west coast oyster growers. Two hatcheries primarily produce cultchless seed, and depend in large part on sales of seed in Europe. The other two commercial hatcheries are associated with organizations which also grow oysters.

Im et al. (1976) provided some insights into west coast oyster seed hatchery problems and their economic viability. The study indicated that hatcheries appear to be economically feasible, but there is some question about "whether more than one or two plants could survive . . . ." The original promise of hatcheries — to guarantee seed of a consistent quality when, where, and in the form needed—although potentially feasible, has not been sufficient to guarantee the survival of a large number of hatcheries.

Hidu (1969) pointed out three obstacles to the successful development of hatcheries: 1) The cost of alternative seed sources; 2) the lack of development in demand for cultchless seed; and 3) the failure to develop genetically superior strains of oysters. The situation has not changed appreciably.

Success in any of the three areas would encourage the development of a hatchery industry. If costs of hatchery seed can be reduced to compete with natural sets, then growers will be more likely to turn to hatcheries. If growers adopt techniques employing cultchless seed, hatcheries already exist to supply that seed. Finally, if genetically superior strains of fast-growing or disease-resistant oysters can be developed, only hatcheries could produce commercial quantities of the new pure strains.

Although the past success for oyster seed hatcheries has been limited, the future holds several encouraging prospects with respect to the obstacles outlined by Hidu (1969). One new idea to reduce the cost of hatchery seed is being tested commercially in Oregon with the sale to growers of setting size larvae by a local hatchery. Setting the larvae on cultch or as cultchless seed will be an activity of the grower, not of the hatchery as in the past.

At this time, very little is known about the overall economics of such an operation. One advantage of a hatchery which sells larvae is that many growers shuck their own oysters and, therefore, have cultch available, thus avoiding the costs of hauling shell to and from hatcheries or natural setting areas.

The traditional independent hatchery producing seed on cultch must acquire shell from growers, set the larvae, and then transport the shell with attached spat back to growers. Handling costs are likewise incurred by growers who take shell to Dabob Bay to catch wild seed. A significant portion of the cost of both is the transportation of the bulky cultch. The farther the grower and the hatchery are from each other and from Dabob Bay, the more likely it is that the larvae technique will be advantageous. It is no surprise, then, that the first oyster larva hatchery on the west coast was built in Oregon, which is a distance from the wild seed source in Dabob Bay, but close to producing areas where oyster shell is abundant. Time will tell if the savings in transportation costs of shell, and the existence of an assured seed source, will be sufficient to make the oyster larva technique competitive with wild seed collection in Dabob Bay.[6]

The second concern expressed by Hidu (1969), the full development of cultural techniques employing cultchless seed, is also receiving considerable attention on the west coast. The existence of an expanding market for half-shell and baking oysters holds considerable potential. In both cases the product sold is a single adult oyster in the shell, and the price is greater than that which the grower receives for equivalent amounts of shucked single oysters broken from clumps of oysters raised on cultch. Since it is usually true

[6]Analysis in this research is based on an assumption that large quantities of wild seed will be available from Dabob Bay on a regular basis. Three or four years of seed failure in Dabob Bay (not likely, but possible), and a continuation of the increase in the price of Japanese seed (very likely), would lead to an immediate and significant improvement in both the acceptability of hatchery seed to growers and economic stability of hatcheries.

that well-formed oysters of a consistent size and shape draw a better price in the half-shell market, the development of techniques employing cultchless seed is indicated.

As discussed, the potential for production of cultchless oysters in trays or cages is probably limited by sociopolitical considerations. Hence, there will be further impetus for developing alternative techniques for growing cultchless oysters.

At least two are presently being explored. The best known technique is the placement of large singles on intertidal lands. The second includes several ideas, collectively known as "out-bay" culture. Out-bay culture is a process of growing oysters in trays and cages in large tanks, raceways, or troughs. The holding areas are constructed near a source of seawater, and pond-raised algae is used as a food source for the growing oysters.

Out-bay culture offers the advantage of increasing control of the environment to the point where storms, silt, predators, and currents are not the problems they are when oysters are raised intertidally. Also, although out-bay culture operations will not be free of sociopolitical constraints, they should be relatively more free than operations which need to construct permanent or semipermanent structures in bays and estuaries. However, a real impediment does exist to the rapid development of out-bay operations. Construction and pumping costs can be very high. At present the technique is experimental and no definitive answer is available on the economic feasibility of out-bay culture methods.

As in so many other areas of the oyster industry, further research is needed in the area of out-bay culture. The real issue, however, is not whether the half-shell or baking oysters are produced intertidally, out-bay, or another way, but the fact that cultchless seed will be needed and hatcheries likely will be the seed source. Therefore, as the market for adult single oysters increases naturally or is induced through marketing promotions, the future of oyster seed hatcheries is enhanced.

Finally, the third area referred to by Hidu (1969), genetics, while now of relatively minor importance, could profoundly affect the oyster industry. For instance, few Pacific oysters are sold in the summer months on the west coast due to the fact that the marketability of oysters declines as the water temperature increases and they approach the onset of spawning.

Another Asian species, *Crassostrea rivularis*, might provide a partial solution. There is speculation, though no conclusive documentation, that it may make an ideal "summer oyster," since it apparently remains firm in west coast waters throughout the summer. A firm oyster available during the summer is potentially very important to the west coast oyster industry. The many coastal summer tourists of Washington, Oregon, and California could provide a large market for such oysters.

A third Asian oyster, and a subspecies of *Crassostrea gigas*, the Kumomoto, may also be produced by hatcheries. The Kumomoto is prized for its small size and as such, commands a price in the market from four to five times that of the Pacific oyster.

The Kumomoto, like *C. rivularis*, also has desirable qualities through the summer. Kumomoto seed used to be imported from Japan, but is no longer available. In the future, hatcheries will be the only source for seed.

An additional issue related to genetics, which can have a positive influence on hatcheries, is the potential development of an "improved" oyster. That is, at some point in the future there is reason to believe a more rapid growing, or a disease-resistant oyster, will be developed. Again, only hatcheries could provide pure strains of such an oyster in commercial quantities. Genetic issues may, in the long run, be of the most importance to the future of hatcheries. When pure strains of oysters are needed, whether they be *C. rivularis*, Kumomoto, or some as-yet undeveloped "improved" oyster, hatcheries likely will be the only source of supply.

Summary

Oyster hatcheries have been in existence on the west coast since 1967 and, despite early promise, have experienced only limited success. Problems include the existence of unpredictable natural sets of oysters in the State of Washington, and the lack of development in cultural techniques employing cultchless seed.

There is, however, reason for optimism. The hatcheries' ability to compete with natural sets is judged to be improving, and there is evidence of a growing demand for types of oyster seed which can not be met with natural seed. More growers are likely to be either switching to or starting up with at least some of their production being cultchless seed.

There is also reason to believe that hatcheries will continue to reduce costs; some by further advancement of techniques and equipment, and some by such radical moves as the sale of larva rather than seed to growers. Finally, and with a somewhat longer view in mind, both the development of genetically superior oyster strains and the adoption of out-bay culture techniques might, some day, make the oyster industry totally dependent on hatchery-produced oyster seed.

West coast oyster hatchery problems need not be viewed negatively. The west coast oyster industry is in a period of transition. What was once an industry of numerous small, family-type operations is now, with respect to production at least, heavily dominated by large family and corporate enterprises. The industry is modernizing and experimenting. Hatchery oyster seed production is just 11 years old on the west coast. As with many innovative movements, there are some failures and some successes. As this period of transition moves toward a close, it is believed hatcheries will find a more secure place in the oyster industry.

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A Mechanical Escalator Harvester for Live Oysters and Shell

D. S. HAVEN, J. P. WHITCOMB, and Q. C. DAVIS

ABSTRACT–A mechanical oyster harvester has been developed by coupling a newly designed head with a chain-link conveyor. The head consists of a rectangular steel frame set on steel runners and two rotating drums armed with spring-loaded teeth. The teeth of the outermost drum rake oysters from the substrate. The teeth of the second drum and water jets impell the oysters to the escalator where they are brought to the surface. Harves' rates of 500 bushels of oysters an hour and 774 bushels of shell an hour have been achieved.

Introduction

A mechanical oyster harvester was designed, constructed and tested in Chesapeake Bay, Va., from 1972 to 1976.[1] It couples the escalator system of a conventional Maryland soft clam dredge with a newly designed head. Revolving spring-loaded teeth attached to two drums in the head pull or rake oysters from the bottom and horizontal water jets and the action of the revolving teeth impel the oysters onto a conveyor belt which carries the oysters to the boat. This design eliminates several problems associated with previously designed harvesters.

Most mechanical devices for harvesting molluscs are based on the design Fletcher Hanks developed in Maryland in 1954 to harvest the soft clam, *Mya arenaria*. It jetted water at high pressure into the bottom just ahead of a boxlike device which slices through the bottom. A blade extending about 16 inches below and slightly behind the jets guides the soft clams loosened by the jets onto a moving chain-link conveyor belt (Manning, 1957).

This design was later modified to harvest oysters in Canada (Medcof and MacPhail, 1955). Wheels were added, and the depth at which the blade cut the bottom was decreased. This oyster harvester was again modified to harvest hard clams, *Mercenaria mercenaria*, and other species (MacPhail, 1961; Godcharles, 1971; and Jolley, 1972).

Two harvesters have been developed on the west coast to harvest the Japanese oyster, *Crassostrea gigas*. One, the Bailey harvester, is very large, and it is based on the principle by which water currents set up by large impellers are used to create a flowing mixture of sand, water, and oysters under a head which rests on and makes a seal with the bottom. The moving oysters are deposited on a conveyor (Bailey, 1950[2]). The device is reportedly about 25 percent efficient (Quayle, 1969).

The second was developed by the Olympia Oyster Company in Washington. This harvester (patent pending) uses three units. The first consists of a 15- × 30-foot barge containing the pilot house, propulsion unit, an air compressor, and a powerful water pump. The second component is open and supports a harvester head and scoop similar to that developed by Hanks, which is towed over the bottom. As this head slides over the bottom, powerful horizontal jets of water sweep the oysters off the bottom into a collecting box. From this latter unit they are transported to the surface through a pipe by the air lift principle. The water-shell mixture is expelled into a barge with a screened bottom (Malloch and Kolbe, 1976).

The cutting blade is a necessary component to all but the Bailey harvester. The cutting blade operates satisfactorily on soft bottoms, but when bottoms contain significant quantities of embedded or buried shells, the scoop often encounters so much resistance that the efficiency of the gear is greatly reduced. Such hard substrates are common in many oyster growing regions.

Design and Construction

The harvester utilizes a conventional chain-link conveyor 39 feet long, suspended from a 40-foot Chesapeake Bay workboat with an 11-foot beam (Fig. 1). The harvester head consists of a rectangular boxlike structure which slides over the bottom on steel runners (Fig. 1, 2). Within this rectangular box are two chain-driven rotating drums powered by a variable speed hydraulic motor located on the top of the box. Each drum has six rows of spring-teeth (Fig. 3). In operation, the harvester's forward drum teeth are set to dig 3 inches into the bottom. The back drum teeth are set, permanently, to rotate flush with the base of the steel runners and about ½ inch forward from a short inclined plane which ends at the escalator belt; the inclined plane is set flush with the steel runners.

To operate the harvester the vessel is moved forward at about ¼ knot (25 feet/minute) and the teeth are set to rotate clockwise, facing the right side, at one revolution per second (60 rpm); at these speeds the harvester head slides forward on the runners and the teeth of the forward rotating drum separates the oysters from the substrate. The back drum teeth sweep oysters and shell

[1] Virginia Institute of Marine Science. 1973. VIMS scientists develop oyster harvester. Mar. Res. Inf. Bull. 5(11):1-2.

[2] R. H. Bailey. 1950. U.S. Patent No. 2,508,087.

loosened by the forward drum up the inclined plane and onto the upward moving escalator belt. Jets of water (50 psi) are directed toward the escalator to help move the oysters or shell up the inclined plane and to wash debris from the shell.

Most of the details of construction and the critical measurements may be obtained from the figures and Appendix, but certain aspects need emphasis.

The central core of each drum is a hollow 3-inch outside diameter (OD) pipe. Each end of this pipe is welded to a circular 5-inch diameter plate reamed at its center to receive a bushing; this basic unit turns freely on a 1⅜-inch stainless steel shaft (Fig. 4). Bolted to each 5-inch end plate is a circular 10-inch plate; around its circumference are six equally spaced 2-inch tapered plugs bolted to the disc. These plugs and their duplicates on the opposite disc hold six 28-inch long 1¾-inch OD hollow pipes. On each pipe are strung (through their central spring coil) the rows of flexible tines. The basal end of each tine is held firmly in a grooved strip welded to the 3-inch pipe. This system of construction allows removal of each row of drum teeth to replace broken teeth.

The cog-wheel drives for the drums are bolted to the outer face of each 10-inch disc.

The depth to which the forward tines penetrate the bottom may be adjusted. Each end of the spindle shaft of the rotating drum nearest the escalator passes through two elliptical steel plates fitted with bushings; this shaft also has bushings in the outer rectangular frame. This construction assures that the spring-loaded teeth always remain in a fixed position relative to the bottom and to the inclined plane. In contrast, the forward rotating drum has its bushings only in the two elliptical plates. Consequently, the forward drum may be adjusted and bolted in the most effective position for a particular type of substrate (Fig. 3, 5).

The high pressure water jets impact on the inclined plane inside the head just behind the after drum unit.

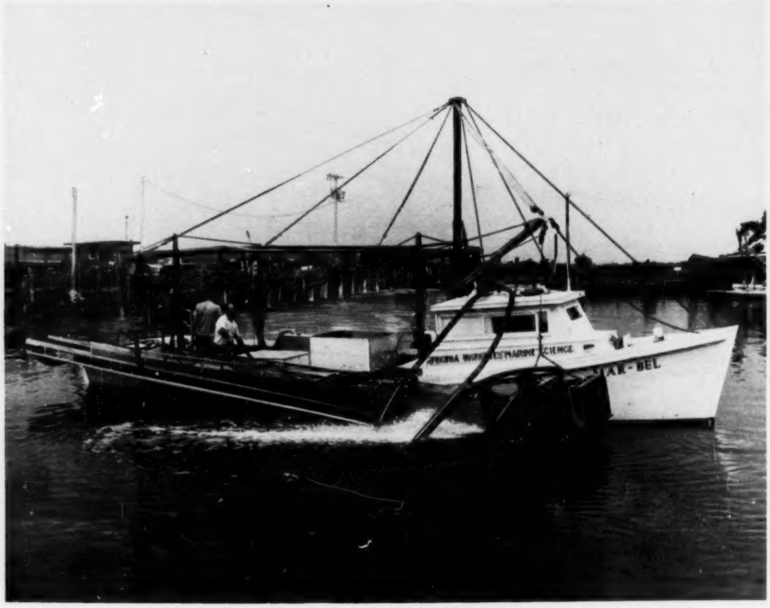

Figure 1.—Research vessel *Mar-Bel* showing escalator and mechanical head. Water pipes to jets are shown on the outside of the rectangular frame.

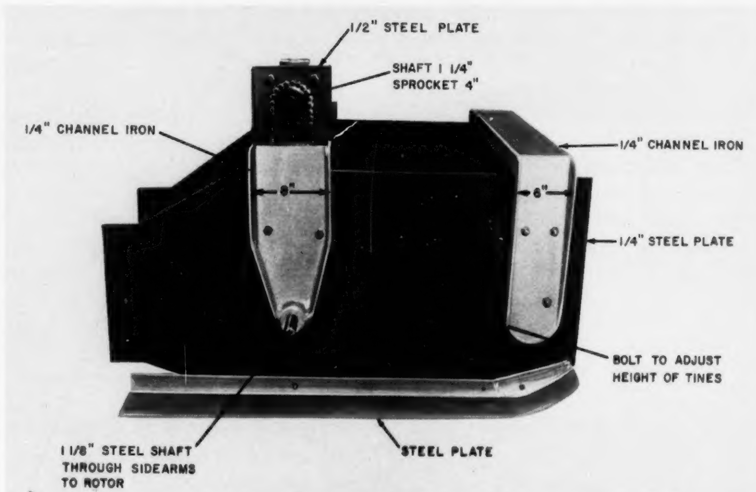

Figure 2.—Side view of escalator during construction showing method of attachment of hydraulic drive motor and details of frame construction.

Field Tests

The harvester underwent extensive field trials in Virginia during 1976 and 1977 on a wide variety of subaqueous substrates. In all instances, it removed the shell and/or oysters in its path to a depth of 3-4 inches.

In a typical trial in the Rappahannock

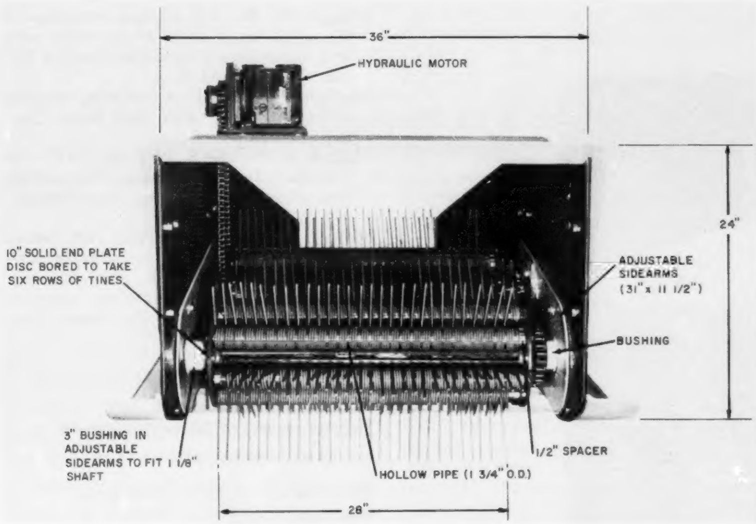

Figure 3.—Front view of head showing details of drums and the steel rake teeth.

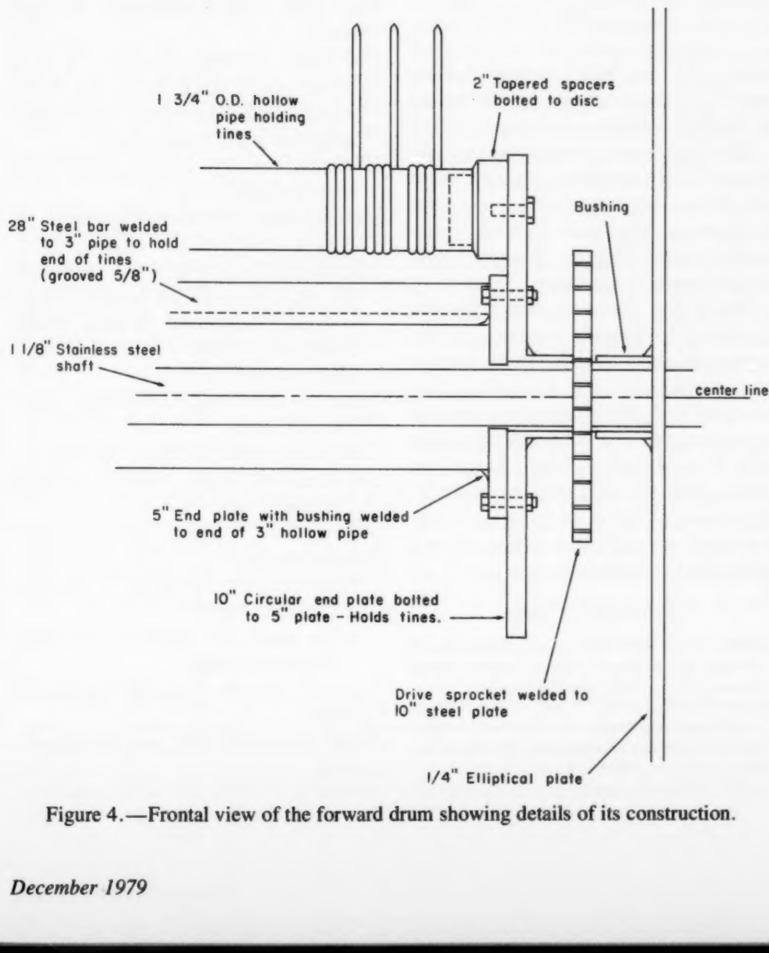

Figure 4.—Frontal view of the forward drum showing details of its construction.

River where seed oysters had been planted and oyster density was high, oysters were harvested at rates ranging up to 138 bushels per hour. The bottom was originally soft mud, but application of 5,000 bushels of shell per acre had firmed the bottom prior to planting the seed oysters.

In the York River on a firm sand-clay bottom where oyster density was very low, it harvested oysters at the rate of 27 bushels per hour. In the same estuary on a very hard shell bottom where oysters were scarce, shell material was raised at rates ranging from 180 to 774 bushels per hour.

In all trials, the oysters raised by the harvester were virtually undamaged. Moreover, the shell material and oysters had been washed free of sand or mud by the action of the jets. In all trials, it was observed that the harvester obtained less than about 5 percent blackened shell material (with the tines set at 3 inches), indicating that the harvester was skimming off only the surface layer and not harvesting the lower anaerobic substrate.

The preceding observations were corroborated by a diver. The harvester was first operated on an oyster bottom where the substrate was a hard matrix of sand, clay, shell, and a few oysters. During this test, shells and oysters were raised at the rates of 774 and 30 bushels per hour, respectively. Inspection of the bottom by a diver showed the teeth had dug a shallow trench 3 to 4 inches deep and 28 inches wide (the width of the rotating drums). The bottom of the trench was firm. It was concluded that the disturbance of bottom substrate was minimal and that it did not exceed that of drag-type oyster dredges.

In 1978 a slightly modified copy of the VIMS harvester was constructed by the North Carolina Division of Marine Fisheries and used during 1978 to harvest seed oysters (Burnett, 1979). The harvester worked well and harvested up to 500 bushels an hour.[3]

[3]Walter Godwin, Regional Coordinator, North Carolina Division of Marine Fisheries, Wilmington, NC 28405, pers. commun. August 1979.

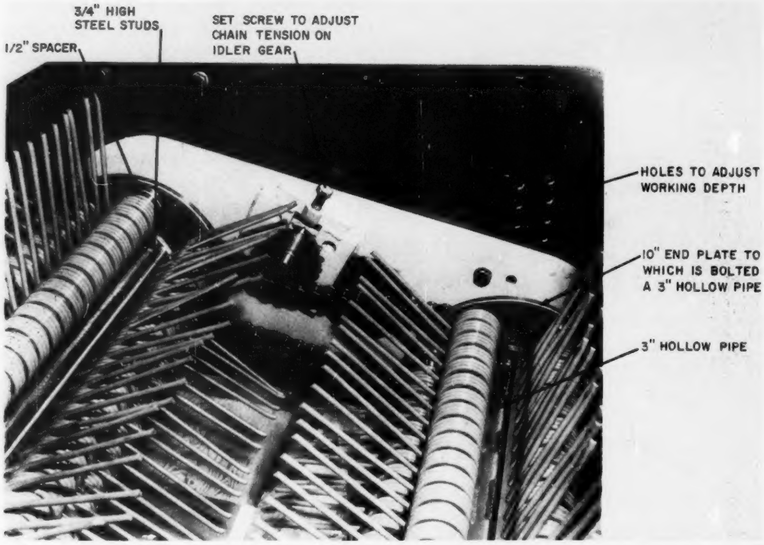

Figure 5.—Details of the elliptical adjustable plate, idler gear, and chain drive.

Discussion and Conclusions

The described harvester performed satisfactorily in a series of trials with catch rates of oysters ranging up to 178 bushels per hour and shell at 774 bushels per hour. A slightly modified design used over a year by the North Carolina Division of Marine Fisheries also performed satisfactorily. Catch rates of about 500 bushels an hour have been reported for this latter unit.

Observations by a diver indicate that when properly operated, only the top 3 to 4 inches of bottom are harvested, and disturbance of the surrounding bottom is minimal.

The harvester developed by VIMS has several advantages over other harvesters. It has no vertical jets which could dig deep trenches in the bottom or a projecting blade which could impede its forward motion on hard shelly bottoms.

During the field trials in Virginia, two persons operated the vessel and the harvester. One person culled the oysters from the belt, another steered and operated the harvester. If oyster density was high, an additional person would be needed to assist in culling.

The harvester constructed by the state of North Carolina utilizes a barge which it positions under the end of the escalator to receive the harvest. If the catch consists largely of oysters this system saves much labor.

While this harvester was primarily designed to harvest oysters, it has proven efficient in raising shell. Shell is an important adjunct to growing oysters since up to 5,000 bushels per acre are often planted as a substrate to collect spat. Cost of shell is about 25 cents per bushel when it is purchased from shucking houses. The use of this gear to obtain shell, we believe, could result in a substantial reduction in cost.

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Appendix

Supplementary Information on Critical Measurements

Box frame: ¼-inch sheet steel.

Bushing: brass.

Chain drive from hydraulic motor: size 50.

Drive sprockets: ⅜-inch thick.

Elliptical steel plate: 31 inches × 11½ inches × ¼ inch.

End plate: 5-inch diameter; ⅜-inch thick.

End plate: 10-inch diameter; ⅜-inch thick; six ⅝-inch holes for bolts around outer diameter; six ⅜-inch holes for bolts around axis.

Hydraulic motor: variable speed (constant torque).

Inclined plane: forward of escalator 18 inches × 12 inches.

Longitudinal bar welded to 3-inch pipe (to hold tines): 28 inches long, ⅞-inch wide, and ⅞-inch high; machined to form a channel ⅝-inch deep, ⅜-inch wide.

Pipes to hold tines: 28 inches long, 1¾-inch O.D.

Rotational speed of drums: 60 rpm.

Set screw to adjust tension: ⅜-inch diameter.

Skid width: 5¾ inches.

Spindle shafts:

- Forward shaft: 28 inches × 1⅛-inch diameter (solid).
- After shaft: 32 inches × 1⅛-inch diameter (solid).

Tapered spacers (2-inch): machined steel.

Water pressure: 50 pounds/square inch.

Development of a Self-Culling Blue Crab Pot

PETER J. ELDRIDGE, V. G. BURRELL, Jr., and GEORGE STEELE

Introduction

Benjamin Franklin Lewis of Harryhogan, Va., revolutionized the blue crab, *Callinectes sapidus*, fishery with the introduction of the crab pot in the middle 1930's (Wharton, 1956). Until then, the most widely employed method of catching crabs was the trot line. It produced about half the catch per man day as did the pot and therefore was rapidly replaced as the preferred fishing gear (Cronin, 1950).

Crab pots were introduced into South Carolina in the early 1950's and commercial catch by this gear was first reported in 1955 (Green, 1952; Anderson and Powers, 1957). The last trot line apparently was used by South Carolina crabbers in 1973 (Pileggi and Thompson, 1976; Wise and Thompson, 1977).

The crab pot is essentially a square cage constructed of 38-mm (1½-inch) galvanized poultry wire with a bait box to attract crabs and funnels to allow them to enter. It is a very efficient means of capturing blue crabs and this results in large numbers of sublegal size (<127 mm carapace width) crabs being retained along with legal size crabs. Numbers of sublegal crabs caught vary with season but are most abundant in May and June when they may make up over 60 percent of the catch (Cronin, 1950; Eldridge and Waltz, 1977; Van Engel, 1959). Law abiding crabbers must then spend considerable time culling out small crabs and returning them to the water. Many of these crabs may not survive as they are often injured by larger crabs while confined in the pot or baskets prior to being returned to the water. Less conscientious crabbers sell poorly culled catches containing many sublegals to processors who cannot legally or profitably handle small crabs.

This problem has led to efforts to develop self-culling pots. Some researchers have investigated the use of panels constructed of larger mesh (Cronin, 1950); entire traps made of larger mesh (Van Engel, 1959, 1961, 1964); or escape rings (ports) (Wootten, 1976). These studies have not been carried to fruition, i.e., all results tested statistically and made public with recommendations as to what changes should be made to crab pots.

Concern by crabbers, processors, and management groups led us to design a study to determine the feasibility of escape ports as a means of reducing the catch of sublegal crabs. It was hoped that the use of escape ports would result in less culling time for crabbers and a more efficient use of the blue crab resource by decreasing crab injuries associated with fishing.

The objectives were to determine if the concept of escape ports was sound and to determine the best configuration and size of escape ports. Criteria for pots with escape ports were: 1) Escape ports must reduce substantially the catch of sublegal crabs, 2) the catch of legal crabs in self-culling pots should not be significantly less than that of the standard pot presently used, and 3) that modification of standard pots to make them self-culling should not involve great expense or labor.

Material and Methods

The work discussed in this report was done in two phases. The first phase completed in the summer of 1977 was designed to test the feasibility of developing a self-culling pot. An associated objective was to determine the optimum configuration (size and number) of rectangular escape ports. The second phase, completed in the summer of 1978, evaluated the relative advantages of circular vs. rectangular escape ports as well as established the "best" configuration (size, number, and placement) of escape ports in commercial crab pots.

Experimental work was done in the Wando River, a small coastal river which flows into Charleston Harbor (Fig. 1). The Wando River was chosen because over 99 percent of crabs taken in it are male and it represents a typical South Carolina estuary where crabs are fished commercially. Experiments were conducted from June through October 1977 and May through August

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ABSTRACT–During 1977 and 1978 a series of experiments was conducted to develop a self-culling blue crab pot. A crab pot with two escape ports in the top chamber and one in the bottom chamber reduced the catch of sublegal crabs by 82 percent. The use of escape ports will reduce culling time of fishermen, reduce law enforcement problems, result in reduced deliveries of illegal crabs to processors, and lower the number of injuries to crabs during the fishing operation.

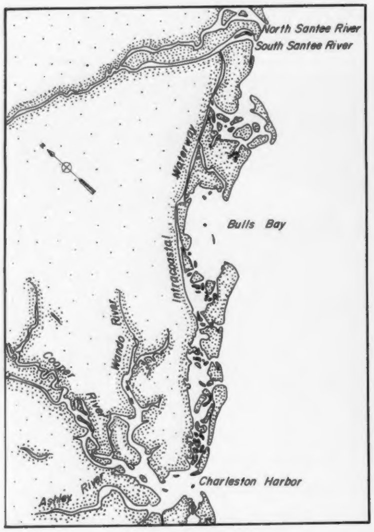


Figure 1.—Wando River where experimental blue crab pot work was conducted.

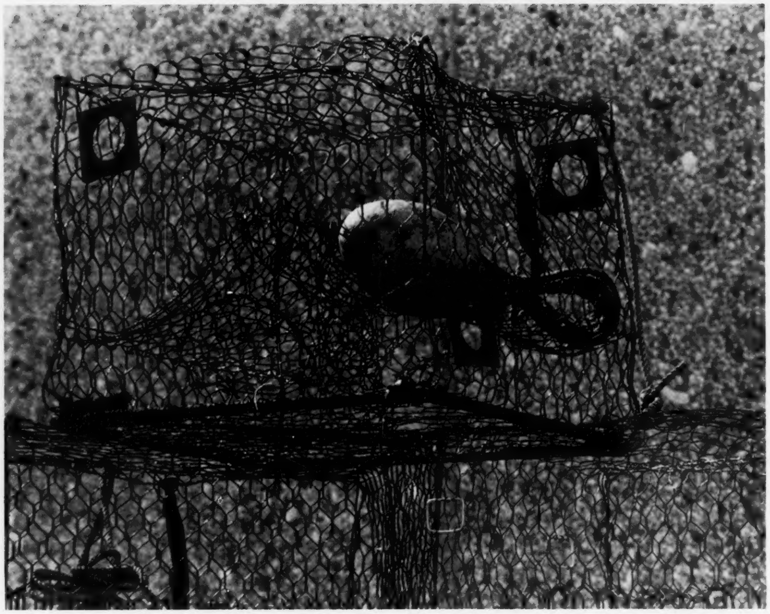


Figure 2.—Experimental blue crab pot with circular escape ports.

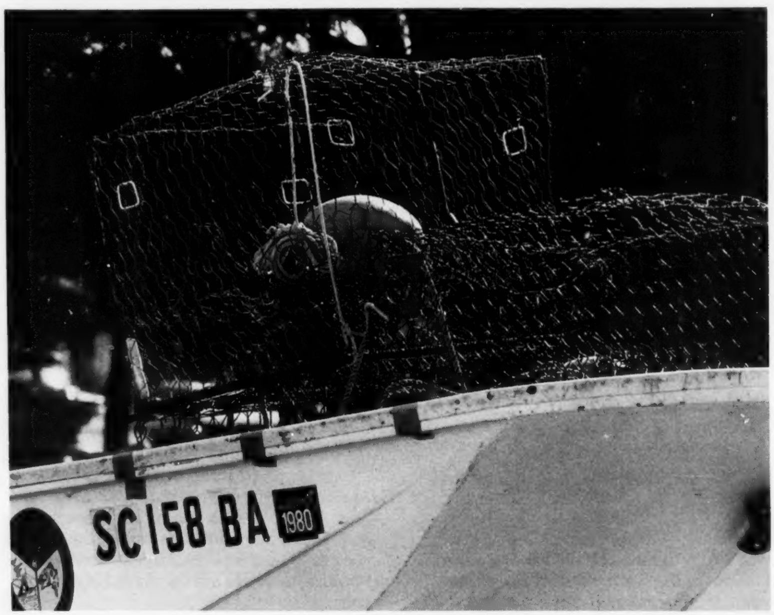
1978. A total of 11,860 crabs were taken during the project. Experimental pots, those with escape ports, were constructed from standard commercial pots. Circular and rectangular escape pots were constructed and placed into pots by personnel of the Marine Resources Research Institute (Figs. 2, 3).

Pots were set on Mondays, pulled and baited daily, and taken up on Fridays to insure uniform fishing time as well as to minimize pot theft. The latter objective was fully satisfied in that only one pot was lost during the project. Pots with different escape port configurations were uniformly mixed throughout the fishing area in order to sample the crab population as randomly as possible.

Carapace length, carapace width, total live weight, sex, stage of maturity, and missing appendages were recorded for crabs during 1977. Similar data were recorded for samples of 1978 catches except that sex and carapace width were collected for all crabs. All data were computerized.

The basic approach to experimental design was to test all practical sizes of

Figure 3.—Experimental blue crab pot with rectangular escape ports.



escape ports in a pilot study. After preliminary testing unsatisfactory ports were eliminated in order to expand most of the experimental effort on the best port sizes and configurations. Criteria selected to determine the best ports were that the ports must substantially reduce the catch of sublegal crabs while maintaining the catch of legal crabs. Escape ports that either failed to reduce the catch of sublegal crabs or resulted in a substantial reduction in the catch of legal crabs were eliminated from consideration after field testing.

Results and Discussion

Field Work, 1977

Work in Virginia by Van Engel during the early and mid 1960's showed that a 2 ×1.5 inch rectangular mesh pot would significantly reduce the catch of sublegal crabs. Based on this finding, the first experiment in the study used rectangular escape ports of 1.50 by x inches where x varied from 1.75 to 2.50 inches in ¼-inch increments. Table 1 shows general information which describes the series of experiments that were conducted in 1977 to select the "best" rectangular escape port.

The first experiment demonstrated that the use of a rectangular escape port 2.5 ×1.5 inches would not be practical because the legal catch was reduced by approximately 50 percent. The first and second experiments demonstrated that a 1.75- × 1.5-inch port did not greatly reduce the catch of sublegal crabs. The first through third experiments indicated that the most promising escape ports were 2.125 ×1.5 and 2.25 ×1.5 inches (Table 1). For this reason experiments 4 and 5 were concerned solely with the latter two escape ports. It should be noted that the 2.0- × 1.5-inch escape port compared well with the unmodified commercial pot, but was not as efficient as the two chosen.

The ratio of legal to sublegal crabs varied considerably between the control pots (standard commercial pots) and those with escape ports (Table 2). The reduction in catch of sublegal crabs was 43.53 and 58.91 percent, respectively, for the 1.5- × 2.125-inch and 1.5- × 2.25-inch escape ports.

Table 1.—Mean carapace width in millimeters and sample size in parenthesis of all crabs taken by escape ports by time period by legal size category in 1977.

Time period	Experiment	Commercial pot (control) Legal	Commercial pot (control) Sublegal	1.75 × 1.5 Legal	1.75 × 1.5 Sublegal	2.00 × 1.5 Legal	2.00 × 1.5 Sublegal
6-10 June	1	139.12 (43)	117.89 (66)	137.47 (53)	117.40 (52)	139.08 (49)	117.25 (36)
27 June-1 July	2	138.76 (72)	118.35 (34)	138.18 (61)	117.75 (28)	139.03 (99)	119.42 (33)
12-22 July	3	140.43 (183)	116.91 (115)			140.89 (174)	117.64 (89)
8-19 Aug.	4	145.47 (394)	117.05 (101)				
26 Sept.-7 Oct.	5	151.35 (378)	115.93 (73)				
Total number		(1,070)	(389)	(114)	(80)	(322)	(158)

		2.25 × 1.5 Legal	2.25 × 1.5 Sublegal	2.50 × 1.5 Legal	2.50 × 1.5 Sublegal	2.125 × 1.5 Legal	2.125 × 1.5 Sublegal
6-10 June	1	140.69 (32)	114.75 (24)	139.42 (19)	114.05 (19)		
27 June-1 July	2	141.72 (57)	115.63 (8)			140.39 (44)	116.42 (24)
12-22 July	3	141.68 (171)	118.48 (29)			140.11 (186)	118.49 (53)
8-19 Aug.	4	146.60 (429)	117.67 (33)			145.58 (407)	118.59 (63)
26 Sept.-7 Oct.	5	151.36 (326)	113.87 (31)			150.35 (344)	113.82 (34)
Total Number		(1,015)	(125)	(19)	(19)	(981)	(174)
Grand total = 4,466							

Table 2.—Numbers of legal and sublegal crabs taken by two most successful sizes of rectangular escape ports tested in 1977.

Time period	Commercial pot Legal	Commercial pot Sublegal	1.5×2.125 escape port Legal	1.5×2.125 escape port Sublegal	1.5×2.25 escape port Legal	1.5×2.25 escape port Sublegal
6-10 June	43	66			32	24
27 June-1 July	72	34	44	24	57	8
12-22 July	183	115	186	53	171	29
8-19 August	394	101	407	63	429	33
26 Sept.-7 Oct.	378	73	344	34	326	31
Total number	1,070	389	981	174	1,015	125
Ratio	2.75		5.64		8.12	
Percent sublegal	26.67		15.06		10.96	
Percent reduction of sublegals			43.53		58.91	

Table 3.—Results of chi-square analyses concerning proportion of legal to sublegal crabs taken in pots with and without rectangular escape ports.

Test	Chi square value	df
Commercial pot vs. 2.125×1.5	30.73**	1
Commercial pot vs. 2.25×1.5	89.19**	1
2.125 vs. 2.25	17.15**	1

**$P<0.01$.

Chi square analyses confirmed that the differences in sublegal catch between the commercial pot (control) and those with escape ports were significantly different (data from experiments 2-5 were used for these tests—Table 3). Also, a chi square analysis showed that the 2.25-inch escape port reduced the catch of sublegals significantly more than did the 2.125-inch port.

The 1977 results clearly demonstrated that the use of escape ports substantially decreased the numbers of sublegal crabs that were retained while maintaining the catch of legal crabs.

Other 1977 Results

It was thought that the use of escape ports might affect the average size of crabs retained by pots. Specifically, we wished to learn if the average size of legal crabs would be increased by using escape ports. We investigated this question by using One-Way Analysis of Variance (ANOVA) for each experiment. We tested the average size of legal crabs taken in control pots vs. the

Table 4.—Results of ANOVA tests to determine if use of escape ports affected the mean carapace widths of legal and sublegal crabs taken during experiments 1-5 in 1977 (each experiment analyzed separately).

Category	*F* value	Probability of obtaining greater *F* value
	Experiment 1	
Legal	0.58	0.6789
Sublegal	1.70	0.1524
	Experiment 2	
Legal	1.34	0.2559
Sublegal	0.75	0.5594
	Experiment 3	
Legal	0.91	0.4383
Sublegal	0.73	0.5411
	Experiment 4	
Legal	1.35	0.2604
Sublegal	0.95	0.3883
	Experiment 5	
Legal	0.74	0.4762
Sublegal	0.97	0.3831

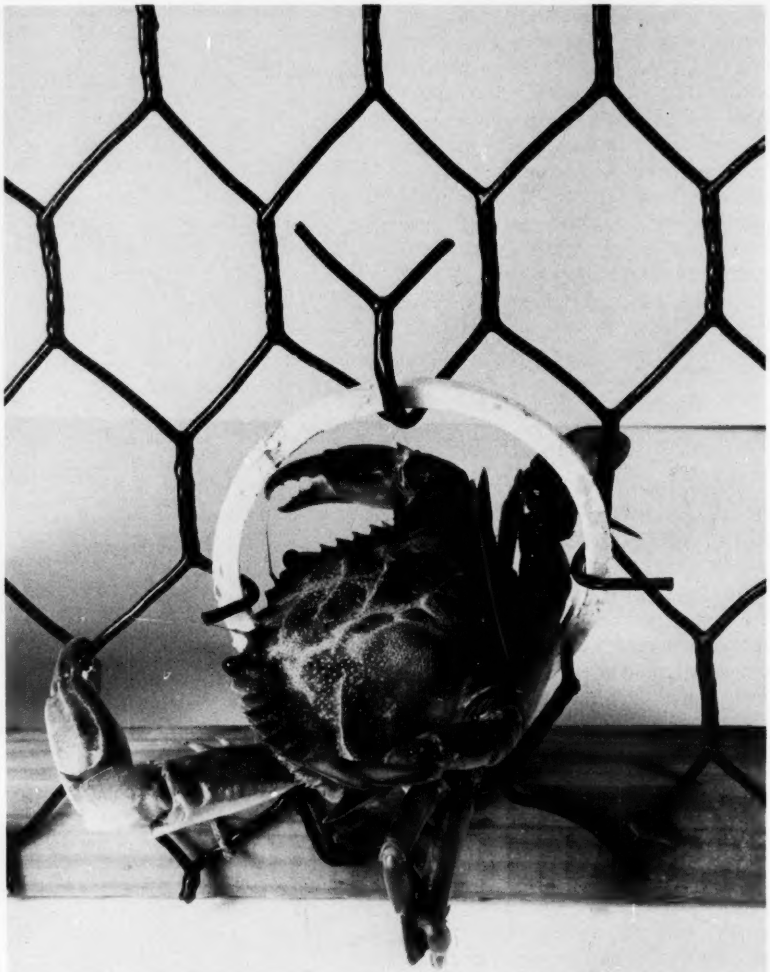


Figure 4.—Sublegal blue crab passing through escape port in experimental pot.

average size of legal crabs in pots with escape ports. A similar test was conducted for sublegal crabs. Results are given in Table 4. The results clearly show that the mean carapace width of both categories (legal and sublegal) was not affected by the use of escape ports within experiments.

The second question was whether the mean carapace width of the two categories (legal and sublegal) changed among experiments. Results are given in Table 5 and show that the mean carapace width did change significantly among experiments for legal crabs which is in agreement with Eldridge and Waltz (1977). The mean carapace widths of sublegal crabs did not appear to change except for the pots using a 1.5- × 2.125-inch ports. There is no reason to believe that the mean size of sublegal crabs should change over time (selectivity of pot should be constant over time), thus, the result observed with the 2.125-inch port appears to be due to experimental error and it was concluded that the mean size of sublegals caught did not change among experiments.

Body Relationships

During 1977, carapace width, length, and total live weight measurements were routinely collected. The following relationships were determined by standard statistical least squares regression procedures: Carapace width-carapace length relationship, total live weight-carapace width, and total live weight-carapace length (Table 6). The latter two relationships were calculated by using the logarithms (base 10) of the weight and respective body measurement. Crabs used in the analysis ranged in size of carapace width from 94 to 184 mm.

Missing Appendages

During 1977, missing appendages were noted to obtain an estimate of damage associated, at least in part, to capture by crab pots. Over one-half (56.67 percent) of all crabs appeared to sustain damage associated either with capture in pots or in transit to the laboratory (Table 7).

Results in 1978

Field work in 1978 lasted from 16 May to 18 August and five separate experiments captured 7,394 crabs (Table 8). An illustration of an escape port in use is shown in Figure 4. The first experiment conducted in May utilized rectangular escape ports, but varied the

Table 5.—Results of ANOVA tests to show differences in mean carapace widths among experiments utilizing commercial pots (control) and those using rectangular escape ports.

Pot	Category	F value	Probability of obtaining greater F value
Commercial	Legal	39.37	0.0001**
Commercial	Sublegal	1.07	0.3707
2.25×1.5	Legal	28.55	0.0001**
2.25×1.5	Sublegal	1.79	0.1351
2.125×1.5	Legal	33.45	0.0001**
2.125×1.5	Sublegal	2.80	0.0409*

Mean carapace width of crabs taken during experiments 1-5 for selected port types

		1	2	3	4	5
Commercial	Legal	139.12	138.80	140.43	145.50	151.30
Commercial	Sublegal	117.89	118.35	116.91	117.05	115.93
2.25×1.5	Legal	140.69	141.72	141.68	146.60	151.56
2.25×1.5	Sublegal	114.75	115.63	118.48	117.67	113.87
2.125×1.5	Legal		140.39	140.11	145.58	150.35
2.125×1.5	Sublegal		116.42	118.49	118.59	113.82

**$P<0.01$.
*$P<0.05$.

Table 6.—Body relationships as determined by standard least squares regression procedures for male blue crabs taken in Wando River, S.C., during 1977. Crabs ranged in size from 94 to 184 mm in carapace width.

Regression equation	R – Square
CW = −10.09221+2.34267 CL[1]	0.86
Log Wt = −3.43615+2.6492 Log CW[2]	0.87
Log Wt = −3.35610+3.10288 Log CL	0.90

[1]CL = Carapace length.
[2]CW = Carapace width.

Table 7.—Incidence of missing appendages observed in 1977 during the blue crab, *Callinectes sapidus*, self-culling crab pot project.

Missing appendages	Number of crabs	Percent of total
Walking legs	1,523	34.10
1 Claw (Cheliped)	302	6.76
2 Claws (Cheliped)	21	0.47
1 Claw & other appendages	373	8.35
2 Claws & other appendages	33	0.74
Back paddle (last walking leg)	132	2.96
Back paddle & other appendages	147	3.29
No injuries	1,935	43.33
Total	4,466	100.00

Table 8.—General catch results of 1978 field work showing legal to sublegal ratios (L:S)[1] and sample size.

Time period	Experiment	Experimental description	No. of traps	Catch	Commercial pot (control)	2.25 2 Ports	2.25 3 Ports	2.25 4 Ports	2.125 2 Ports	2.125 3 Ports	2.125 4 Ports	Total no. of crabs
16-26 May	1	Rectangular ports		L	67	82	68	77	72	82	54	
		(2.25×1.5 vs. 2.125×1.5)	24	S	130	52	48	31	70	78	63	974
		No. of Ports=2, 3, or 4		Ratio L:S	0.52	1.58	1.42	2.48	1.03	1.05	0.86	
					Commercial pot	2.25	2.375	2.50	2.625			
1-9 June	2	Circular ports		L	95	81	114	79	44			
		(2.25,2.375,2.50,2.625)	25	S	148	122	56	35	34			808
		No. of ports = 2		Ratio L:S	0.64	0.66	2.04	2.26	1.29			
					Commercial pot	2T+2B[2]	2T	2T+1B	1T+1B			
14-23 June	3	2.375 Circular port		L	160	156	209	166	179			
		Configuration test	25	S	186	63	94	60	82			1,355
				Ratio L:S	0.86	2.48	2.22	2.77	2.18			
					Commercial pot	2T+2B	2T	2T+1B	1T+1B			
28 June-14 July	4	2.50 Circular port		L	231	245	224	220	232			
		Configuration test	25	S	207	43	89	35	71			1,597
				Ratio L:S	1.12	5.70	2.52	6.29	3.27			
					Commercial pot	2.375 (2T+1B)	2.375 (1T+1B)	2.5 (2T+1B)	2.5 (1T+1B)			
26 July-18 Aug.	5	Circular ports		L	430	378	455	469	485			
		(2.50 vs. 2.375)	25	S	191	65	90	37	60			2,660
		Configuration test		Ratio L:S	2.25	5.82	5.06	12.68	8.08		Grand total	7,394

[1]L=legal crabs ≥127 mm in carapace width; S=sublegal crabs <127 mm in carapace width.
[2]T=top chamber of crab pot; B=bottom chamber of crab pot.

number of escape ports from two to four per pot. The best rectangular escape port configuration was four escape ports measuring 2.25×1.5 inches. That pot had a legal:sublegal ratio of 2.48 which was approximately five times better than the control (standard commercial pot) (Table 8).

The second experiment was designed

to test several circular escape ports in which inside diameters varied from 2.25 to 2.625 inches. The 2.375-inch escape port was one that was developed and tested during the summer of 1977 by the Office of Conservation and Management. This escape port had shown promise (Whitaker[1]). Each pot used in this experiment had two escape ports in the top chamber. The results clearly indicated that escape ports with 2.50- and 2.375-inch inside diameters were superior.

The third and fourth experiments were chosen to test the best number and placement of the 2.375- and 2.50-inch ports, respectively. The combinations used were two ports top chamber with two ports bottom chamber, two ports top chamber only, two ports top chamber with one port in bottom chamber, and one port top chamber with one port in bottom chamber. The results of these experiments indicated that two top ports with one bottom port was superior for both the 2.375- and 2.50-inch size (Table 8).

The final experiment was conducted to determine the "best" size and placement of ports. In this experiment the 2.375- and 2.50-inch ports with two top and one bottom or one top and one bottom were utilized. The latter was used because it may be somewhat advantageous from an implementation viewpoint to use the fewest number of rings possible.

The results of the final experiment indicated that the 2.50-inch port, two top and one bottom configuration was superior to all others. However, the 2.5-inch, one top and one bottom was also good. The former configuration resulted in a reduction in catch of sublegals of 82 percent, whereas the latter configuration reduced the catch of sublegals by 67 percent (Table 9). A chi-square analysis confirmed that the pot with three ports reduced the catch of sublegal crabs significantly more than did the pot with two. Both configurations of escape ports caught more crabs than did the control, which satisfies the original condition that the self-culling pot should at least maintain the catch of legal crabs.

Potential Benefits of Self-Culling Crab Pots

An obvious, but difficult to measure, benefit of using self-culling pots is the elimination of culling time by fishermen. The results indicate that over 80 percent of the sublegal catch would be eliminated. Since culling time is roughly directly proportional to the number of sublegals taken, one can project that culling time would be reduced about 80 percent.

However, the above statement applies only to conscientious fishermen. Eldridge and Waltz (unpublished data) noticed that culling efforts of individual fishermen varied substantially with a majority of fishermen having less than 5 percent sublegal crabs, whereas others commonly had 40 to 50 percent illegal crabs. It was a minority of crabbers that accounted for the total catch being comprised of approximately 10 percent sublegal crabs. Conscientious crabbers will have less culling to perform with escape ports and their catches as before will contain very few sublegal crabs.

The greatest beneficial impact of using escape ports will occur when less conscientious crabbers use them. Their catch of sublegal crabs should be reduced from the 40 to 50 percent range to approximately 10 percent even if they continue to do little or no culling. The reduction in capture of sublegal crabs will result also in a reduction of sublegal crabs delivered to processors. This should make the picking operation more efficient because of the elimination of smaller crabs.

Table 7 shows the incidence of missing appendages recorded during the study. Although some of the injuries may not have been caused by the fishing operation, it is probable that the majority were because of the freshness of the wounds observed. It is impossible to translate the incidence of missing appendages into mortality rates, however, it is logical to assume that some mortality occurs. Also, Van Engel (1958) reported that injuries, such as the loss of legs, could substantially reduce the change in size when a crab molts. This implies that a reduction in injuries certainly would not adversely affect the present growth rate of crabs and might even improve it. Moreover, many fishermen believe that substantial numbers of sublegal crabs are injured or killed when they are associated with larger crabs while in pots and in baskets prior to the time they are thrown overboard. This belief should help fishermen to accept the concept of self-culling pots and, in fact, some fishermen have been quite outspoken in their support of such a measure (Wootten, 1976).

Summary and Recommendations

The concept of using escape ports (rings) to reduce the catch of sublegal crabs without reducing the catch of legal crabs was tested and found to be valid. The "best" self-culling pot that was developed was one that employed 2.50-inch inside diameter escape ports with two in the top chamber and one in the bottom chamber. The reduction in catch of sublegal crabs was 82 percent.

The use of escape ports will reduce culling time of fishermen, reduce law enforcement problems associated with the sale of sublegal crabs, result in

Table 9.—Summary of crab catches utilizing the "best" configurations of the 2.50-inch escape port versus the standard commercial pot.

Item	Commercial pot (control)	2.50 escape port (2 top + 1 bottom)	2.50 escape port (1 top + 1 bottom)
Legal	661	689	717
Sublegal	398	72	131
Legal:Sublegal	1.66	9.57	5.47
Reduction in sublegal crabs	—	82%	67%
Percent of sublegal crabs in catch	37.58	9.46	15.45

[1]Whitaker, D. J. 1978. Data report for escape ring study. Unpubl. manuscr., 11 p.

reduced deliveries of illegal crabs to processors, and lower the number of injuries to crabs during the fishing operation.

The authors strongly recommend the adoption of escape ports as a management measure. However, while the present study documents the most efficient size and configuration of escape ports for South Carolina, we also recommend that pilot studies be conducted in other areas in order to insure the most efficient port size for any particular area. Based on our experience, it should be relatively easy to conduct the necessary pilot studies.

Acknowledgments

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Composition of Catches Made by Anglers Fishing for Summer Flounder, *Paralichthys dentatus*, From New Jersey Party Boats in 1978

DARRYL J. CHRISTENSEN and WALTER J. CLIFFORD

ABSTRACT–Anglers were interviewed while fishing for summer flounder, Paralichthys dentatus, *along the New Jersey coast from party boats. Mean seasonal catch rates for full-day and half-day anglers were 3.15 and 1.86 summer flounder per man per trip, respectively, from 19 June to 1 September 1978. Other fish species made up less than 10 percent of the catch. A total of 828 summer flounder were measured and ages were determined for 427 specimens. Analysis of the age-length data indicates that II +, III +, IV +, V +, and >V + age summer flounder made up 4.3, 73.0, 20.3, 1.8, and 0.6 percent of the catch, respectively.*

Introduction

The summer flounder, *Paralichthys dentatus,* is a highly prized food fish sought by both recreational and commercial fishermen along the New Jersey coast. McHugh (1977) summarized the commercial and recreational catches from 1960 through 1975. He found that New Jersey commercial catches declined from a high of 2,882 metric tons (t) in 1960 to a low of 578 t in 1969, and then increased to 1,957 t in 1975. While the New Jersey recreational catches of summer flounder have not been estimated, the regional recreational catches from New Jersey through North Carolina in 1960 (Clark, 1962), 1965, (Deuel and Clark, 1968), and 1970 (Deuel, 1973) were approximately equal to the commercial landings in the same area and years (McHugh, 1977). This survey was conducted to document the current catch rates made aboard party boats in New Jersey as well as the size and age composition of this component of the total fishery.

Angler interviews and other data were collected aboard party boats fishing between Sandy Hook and Barnegat Inlet from just outside the surf zone up to 1 mile offshore. Both full-day party boats, which usually make a single 7-9 hour trip, and half-day party boats, which usually make a 4-5 hour trip each morning and afternoon, were surveyed for catch rates and size and age composition.

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Methods

Seventeen sampling dates were picked randomly from a 12-week period beginning 18 June and ending 10 September 1978. A list was prepared in June containing the names of the full-day and half-day party boats in Atlantic Highlands, Belmar, Brielle, and Point Pleasant, N.J., which advertised "fluke" (summer flounder) fishing. A boat was chosen randomly without replacement from the list for sampling on each of the 17 scheduled days.

On the scheduled day the sampler identified himself to the captain, explained sampling procedures, offered to pay full fare and asked permission to sample aboard the vessel. If the captain refused or the scheduled boat did not sail, an alternate vessel was chosen from the same port. If the boat was a half-day boat, the sampler went aboard both the morning and afternoon trips. Survey personnel counted each angler who actively fished, measured fish to the nearest centimeter total length, and collected scale and dorsal fin ray samples for subsequent age analysis. During the trip back to port, individual anglers were interviewed to determine their catch for the trip.

Plastic impressions of the summer flounder scales were used to age fish according to basic fisheries techniques (Everhart et al., 1975). Thin cross sections from the bases of dorsal fin rays were used to verify the ages indicated by the scales.

Results and Conclusions

A survey of the ports in mid-June indicated 6 full-day and 14 half-day boats advertising summer flounder fishing. On the 17 randomly chosen sampling dates, 5 full-day and 12 half-day boats were selected for sampling. Survey personnel completed all of the scheduled trips except for two half-day afternoon trips. Several of the vessels which advertised summer flounder trips in June changed to fishing for blue fish, *Pomatomus saltatrix*, in late July or August. A list of the dates, ports, vessel type, number of trips, and number of anglers per trip is presented in Table 1.

A total of 935 out of 1,383 anglers aboard the vessels were interviewed. The combined catch of 139 full-day anglers was 438 summer flounder with a mean of 3.15 fish per angler trip. The combined catch of 796 half-day anglers was 1,484 summer flounder with a mean of 1.86 fish per angler per trip. Full-day boats carried 30 anglers and landed an estimated mean of 96 summer flounder per boat trip while

half-day boats carried a mean of 56 anglers per trip and landed an estimated mean of 104 summer flounder per boat trip.

The catches of individual anglers were examined on a trip-by-trip basis. This examination revealed that a distinct change in the success of individual anglers occurred between 10 and 11 July. Prior to July, only 10 percent of the full-day anglers an 11 percent of the half-day anglers failed to catch at least one summer flounder. After 11 July, 49 and 54 percent of the full-day and half-day anglers, respectively, were unsuccessful. The change in proportion of successful fishermen is readily apparent as illustrated in Figure 1. The cause of the decline in catch is unknown. It was sufficient to reduce the mean catch per full-day angler from 5.22 before 11 July to 1.49 after 11 July and to reduce the mean catch per half-day angler from 3.00 before 11 July to 1.06 after 11 July.

Other species were caught incidental to the catch of summer flounder. The total incidental catch of the 935 anglers interviewed was 62 windowpane, *Scophthalmus aqosus;* 40 smooth dogfish, *Mustelus canus;* 52 searobins, *Prionotus* sp.; 33 black sea bass, *Centropristis striata;* 8 bluefish, *Pomatomus saltatrix;* 2 banded rudderfish, *Seriola zonata;* 2 skates, *Raja* sp.; 1 sand tiger, *Odontaspus taurus;* and 1 unidentified "sand" shark, *Carcharhinus* sp. The incidental catch was only 201 fish or less than 10 percent of the total numbers of all fish caught by the anglers interviewed.

During the survey 828 summer flounder were measured and 427 age samples collected. Both number and percent frequencies of all fish measured and those from which age samples were collected are presented in Table 2. The ages at length for each centimeter group in the age sample is given in Table 3. It was assumed that all fish not aged which measured less than 27 cm were II + fish and all those measuring over 59 cm were older than V + fish. The percentage of each age at each length group was multiplied by the total number of fish measured in that group to determine the numbers caught for each age group (Table 4). The percent age composition of the catch (Table 4) was 4.3, 73.0, 20.2, 1.9, and 0.6 for II +, III +, IV +, V +, and >V + fish, respectively.

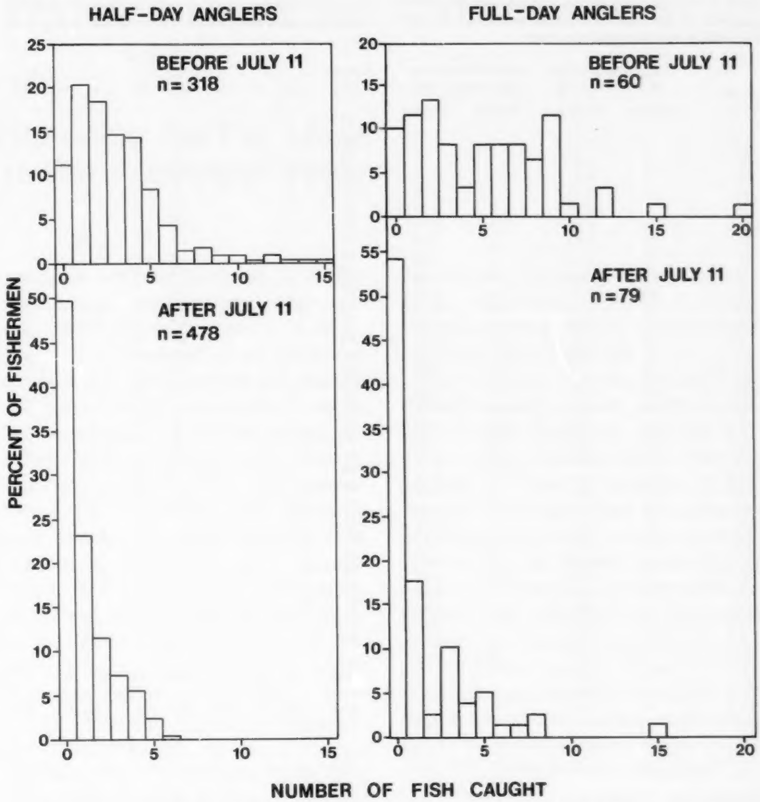

Figure 1.—Distribution of individual catches of full-day and half-day anglers before and after July 11.

Table 1.—Dates, ports, boat types, number of trips, and number of anglers aboard New Jersey party boats sampled for summer flounder catches in 1978.

			No.	No. of anglers aboard the vessel		
Date	Port	Boat type	of trips	Full-day	a.m.	p.m.
6/19	Point Pleasant Beach	½-day	2		36	58
6/23	Belmar	½-day	2		54	30
6/25	Point Pleasant Beach	½-day	2		74	65
6/29	Atlantic Highlands	Day	1	39		
7/01	Point Pleasant Beach	½-day	2		98	102
7/10	Brielle	Day	1	30		
7/12	Belmar	½-day	2		78	56
7/18	Brielle	Day	1	44		
7/20	Belmar	½-day	2		50	35
7/25	Point Pleasant Beach	½-day	2		111	65
8/01	Point Pleasant Beach	½-day	1		15	—
8/11	Belmar	½-day	2		42	25
8/12	Point Pleasant Beach	½-day	2		48	63
8/15	Brielle	Day	1	24		
8/22	Brielle	½-day	1		54	—
8/24	Belmar	½-day	2		32	40
9/01	Brielle	Day	1	15		

Table 2.—Length frequencies and percent length frequencies of 828 summer flounder measured and 427 from which age samples were taken.

Length (cm)	Length frequencies all fish measured		Length frequencies age sampled fish	
	Number	Percent	Number	Percent
23	4	0.48		
25	4	0.48		
26	6	0.72		
27	6	0.72	1	0.23
28	6	0.72	2	0.47
29	10	1.21	3	0.70
30	19	2.29	8	1.87
31	17	2.05	6	1.40
32	41	4.95	26	6.09
33	59	7.13	29	6.79
34	70	8.45	39	9.13
35	66	7.97	41	9.60
36	79	9.54	46	10.77
37	45	5.43	22	5.15
38	61	7.37	37	8.66
39	38	4.59	17	3.98
40	69	8.33	35	8.19
41	38	4.59	23	5.39
42	32	3.86	15	3.51
43	37	4.47	16	3.75
44	26	3.14	15	3.51
45	17	2.05	5	1.17
46	17	2.05	11	2.58
47	10	1.21	4	0.94
48	12	1.45	5	1.17
49	3	0.36	2	0.47
50	9	1.08	4	0.94
51	3	0.36	1	0.23
52	5	0.60	4	0.94
53	2	0.24	1	0.23
54	8	0.97	4	0.94
55	4	0.48	3	0.70
60	1	0.12		
61	1	0.12		
64	1	0.12		
65	1	0.12	1	0.23
66	1	0.12	1	0.23

Table 3.—Age and length of summer flounder caught by anglers aboard party boats in New Jersey during 1978.

Length (cm)	Age class							
	0+	I+	II+	III+	IV+	V+	VI+	VII
27			1					
28				2				
29				3				
30			3	5				
31			1	5				
32				24	2			
33			1	26	2			
34			1	36	2			
35				36	5			
36			1	43	2			
37				19	3			
38				29	8			
39				15	2			
40				26	9			
41				15	7	1		
42				10	5			
43				11	5			
44				11	4			
45				3	2			
46				2	7	2		
47				1	3			
48				1	4			
49					2			
50				1	3			
51					1			
52				1		3		
53					1			
54					2	2		
55					1	2		
64								
65								1
66								1
Class total	0	0	8	325	82	10	0	2
Percent total	0.0	0.0	1.9	76.1	19.2	2.3	0.0	0.5

Table 4.—Expanded numbers, percent age composition, and mean length at age of the party boat summer flounder catch.

Length (cm)	Age class				
	II+	III+	IV+	V+	>V+
23	4				
25	4				
26	6				
27	6				
28		6			
29		10			
30	7	12			
31	3	14			
32		36	3		
33	2	53	4		
34	2	64	4		
35		58	8		
36	2	73	4		
37		39	6		
38		48	13		
39		28	10		
40		51	18		
41		24	12	2	
42		21	11		
43		25	12		
44		19	7		
45		10	7		
46		3	11	3	
47		3	7		
48		2	10		
49			3		
50		2	7		
51			3		
52		1		4	
53			2		
54			4	4	
55			1	3	
60					1
61					1
64					1
65					1
66					1
Total number	36	604	167	16	5
Percent by age class	4.3	73.0	20.2	1.9	0.6
Mean length at age	28.3	36.8	42.2	50.6	

The mean total lengths at time of capture for age II+, III+, IV+, and V+ fish were 28.3, 36.8, 42.2, and 50.6 cm, respectively (Table 4).

Samples of fish from recreational surveys have been aged using otoliths instead of scales by Poole (1961) for Great South Bay, N.Y., and by Smith and Daiber (1977) for Delaware Bay. Smith and Daiber concluded that the first well defined annuli in the otoliths were formed at age II and their ages agreed with Poole's ages when adjusted 1 year forward. The ages of coastal New Jersey summer flounder determined in this study confirm the observations of Smith and Daiber.

Acknowledgments

We wish to express our appreciation to Robert Matus, William Rogers, Russel Terranova, and Paul Yuschak for collecting the field data and Gary Shepard for determining ages of sampled fish. We also appreciate the cooperation of the captains who allowed us to work aboard their vesssls.

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Financing Set For Large Trawler-Processor Vessel

The Federal government signed off in late September on a $5 million financing arrangement—the largest single fishing vessel financing ever guaranteed by the Fishing Vessel Obligation Guarantee program. The announcement was made by Terry L. Leitzell, Assistant Administrator for Fisheries, National Oceanic and Atmospheric Administration (NOAA). The guarantee program is administered by NOAA's National Marine Fisheries Service.

A Commerce Department agency, NOAA said the $5 million guaranteed financing involved the fishing vessel *American No. 1*. The *American No. 1* is a 160-foot, $7 million, trawler-processor intended for operation in the North Pacific Ocean and Bering Sea fisheries. The ship is one of the largest and most advanced trawler-processors ever constructed for the American fisheries, Leitzell said. He added that it should have major implications for the domestic development of a mid-water and bottomfish capability in an area of the U.S. 200-Mile fisheries zone with one of the greatest concentrations of foreign fishing effort.

The long-term debt portion of the vessel's $7 million construction cost was financed by a $5.25 million obligation guaranteed under the Fishing Vessel Obligation Guarantee program. The Federally guaranteed financing has a repayment maturity of 25 years and an interest rate of 9.5 percent. The equity portion of the vessel's $7 million construction cost was generated by a $1.75 million tax-deferred contribution under the Fishing Vessel Capital Construction Fund, also administered by the National Marine Fisheries Service.

The *American No. 1* is the first American fishing vessel ever to be equipped with an automatic trawling system and a computerized sonar system. According to the vessel's builder, this " . . . combination of automatic trawling and computerized fish-finding will permit the *American No. 1* to intercept schools of fish by using automatic net positioning and a moving electronic portrayal of the fishing situation." The vessel has five operating deck levels and a refrigerated hold capacity of 25,500 cubic feet. Its electronic fish-finding and navigation equipment alone involved and investment of more than $500,000. The vessel has quarters for a crew of 21 fishermen and process workers.

The Fishing Vessel Obligation Guarantee program, under Title XI of the Merchant Marine Act, 1936, uses the private capital market to arrange long-term debt financing for up to 87.5 percent of the cost of constructing, reconstructing, or reconditioning U.S. fishing vessels. Financing maturities may in some cases be for up to 25 years, but are generally limited to 15-20 years. The program is self-supporting and receives no governmental funds for its administration. The Federal guarantee is for 100 percent of the financing, is incontestable, and is backed by the full faith and credit of the United States. With a Federal Guarantee under the program, private capital markets are willing to extend longer debt maturities, at a more reasonable interest rate, and for a greater portion of the vessel cost than might otherwise be the case. Additionally under this program, the National Marine Fisheries Service holds, in the Government's name, and services all collateral for the financing—thus making the guaranteed financings more attractive to private capital markets. Although the *American No. 1* represented the largest financing under the program, guaranteed financing is equally available to any fishing vessel which measures over 5 net tons.

The Fishing Vessel Capital Construction Fund program, under Section 607 of the Merchant Marine Act, 1936, enables fishing vessel owners or operators to defer the payment of Federal tax on income from the operation of fishing vessels of 2 net tons or over. This enables fishermen to accumulate before-tax dollars, rather than after-tax dollars, with which to fund the equity portion of fishing vessel construction costs. Thus, vessel downpayments may be accumulated faster and the portion of vessel construction costs which has to be financed with expensive debt may be substantially reduced. Deferred taxes are eventually recaptured over the depreciable life of vessels using the program.

Brochures describing both these Fisheries financing programs are available by calling 202-634-7496 or writing Financial Services Division, National Marine Fisheries Service, NOAA, Washington, DC 20235.

TUNAS INDUCED TO SPAWN IN CAPTIVITY FOR THE FIRST TIME

The first successful attempt to induce spawning in tunas was announced by Richard S. Shomura, Director of the Honolulu Laboratory, Southwest Fisheries Center, National Marine Fisheries Service, NOAA.

The tuna, *Euthynnus affinis*, known locally as kawakawa, was successfully induced to spawn for the first time anywhere in shoreside tanks at the Kewalo Research Facility of the Honolulu Laboratory. Conducting the

spawning experiments at the Kewalo Research Facility is Calvin M. Kaya, a visiting fishery scientist on a year's sabbatical leave from Montana State University.

Kaya explained that this is the first time a species of tuna has been artificially forced to spawn (by hormone treatment) in captivity anywhere in the world. There have been reports from Japan of tunas spawning in artificial enclosures in bays, but these fish spawned naturally without human intervention or control. The Japanese have also obtained fertilized tuna eggs by stripping ready-to-spawn fish caught at sea, but such fish are only rarely captured.

Many fishes, and some terrestrial animals also, for various reasons fail to reproduce in captivity. Consequently, fishery scientists throughout the world have been conducting experiments to artificially induce fishes to spawn in captivity, expecially for aquaculture purposes. Kaya noted that freshwater fishes have been successfully induced to spawn by hormone treatments for many years but the success rate for saltwater fishes, particularly the large, fast-swimming, pelagic species like the tunas has not been as good.

Shomura noted that perhaps it is not surprising that the breakthrough in inducing tunas to spawn occurred in Hawaii in that the Honolulu Laboratory is the only scientific facility in the world which is able to capture tunas at sea, transport them back to shore alive, and maintain them in shoreside tanks and oceanaria throughout the year. Indeed, this was the reason that prompted Kaya to spend his sabbatical leave conducting spawning experiments on tunas at the Honolulu Laboratory's Kewalo Research Facility.

Since the beginning of his experiments, two individual female kawakawa were induced to spawn, said Kaya. The experimental procedure to induce spawning involves conducting biopsies on the fish to monitor the development of eggs in the ovaries. Because the kawakawa, like other tunas, is highly active, special handling procedures had to be developed in immobilizing the fish to conduct the biopsies. Once these techniques were perfected and the biopsies showed that the fish were ready for hormone treatments, Kaya and his assistants began injecting various hormones into the muscles of male and female fish. Following two separate injections of hormones a day apart in mid-June, a female kawakawa spawned (discharged her eggs) into the holding tank. The second female receiving a similar treatment in early July spawned on 4 July. Eggs stripped from the second kawakawa were successfully fertilized by mixing them with milt (the male sex product) from a ripe male. The fertilized eggs hatched into tiny kawakawa which survived for 2-3 days.

This breakthrough in inducing tunas to spawn opens up many possibilities not only in fishery science, but also in commercial marine aquaculture. Plans are to continue these experiments to perfect the techniques at the Kewalo Research Facility so that tunas can be routinely induced to spawn in captivity.

Rote Named to NMFS Post

James W. Rote has been named Director, Office of Habitat Protection, National Marine Fisheries Service, Terry L. Leitzell, National Oceanic and Atmospheric Administration's Assistant Administrator for Fisheries, has announced. Rote advises the Assistant Administrator and the Service on the environmental impact of human activities on the Nation's commercial and recreational fisheries and other living marine resources and their habitats. NOAA is an element of the Commerce Department.

"We are quite fortunate to have a person with Dr. Rote's qualifications and knowledge join the Service," said Leitzell. "The work of the Office of Habitat Protection is becoming more important as the country expands its efforts for new energy sources to the sea. We must be aware of the effects of these new efforts and be assured that we do not destroy or damage our living marine resources while expanding our search for energy," said Leitzell.

Rote has served as an Assistant Secretary and the Acting Deputy Secretary to the California Secretary for Resources and as a member of the California Coastal Commission. He also has been a consultant to the Director of the Bureau of Land Management and a Research Associate with the John Muir Institute in California. He holds a Ph.D. degree in Biological Sciences from Stanford University and a B.A. degree in Economics from Boston University.

Four Major NMFS Positions Filled

Four appointments to major positions in the National Marine Fisheries Service have been announced by Terry L. Leitzell, Assistant Administrator for Fisheries, National Oceanic and Atmospheric Administration.

Martha O. Blaxall is the Director, Office of Utilization and Development; Richard E. Gutting, Jr., is the Director, Office of Policy and Planning; Samuel W. McKeen is the Deputy Director, Office of Policy and Planning; and Robin Waxman has been appointed Special Assistant to Leitzell. Waxman has a B.S. degree in International Affairs and a J.D. degree in Law from Georgetown University.

Blaxall is responsible for preparing and implementing plans for the proper development and use of marine fishery resources. She served as Director, Office of Research; Office of Policy, Planning, and Research; Health Care Financing Administration; Department of Health, Education and Welfare, prior to her new position. Blaxall has the Ph.D. and Masters degrees from the Fletchers School of Law and Diplomacy, Tufts, University. She has been a budget examiner, Office of Management and Budget, and has worked in the National Academy of Science.

Gutting is responsible for evaluating and reviewing the status of current plans and policies and recommends

development of new policies as needed. He has served as General Counsel for the Service, and Counsel for the House Subcommittee on Fish and Wildlife Conservation and the Environment, Council on Environmental Quality, and the Environmental Defense Fund.

McKeen previously served in the Department of Commerce as the Supervisory Budget Analyst for NOAA programs. He has a B.S. degree from the University of Maryland in Business and Public Administration and has worked in the Department of Commerce for more than 10 years.

Program to Expand Alaska Fishing Industry Started

A $1,350,000 program designed to let Alaska fishermen evaluate their capacity for catching species of groundfish now being taken by foreign vessels within the 200-mile limit has been announced by Richard A. Frank, Administrator of the National Oceanic and Atmospheric Administration (NOAA). Under a cooperative agreement between NOAA's National Marine Fisheries Service and the Alaska Fisheries Development Foundation, the program will begin to test the economic feasibility of using existing U.S. fishing vessels to harvest bottomfish resources.

More than 500 foreign fishing vessels now harvest more than 3 billion pounds of groundfish each year from waters off Alaska. The resource represents a potential for multibillion dollar industry for U.S. fisheries, and employment for thousands in Alaska and elsewhere in fishing, processing, shipbuilding, and food processing.

The agreement initiates the first of a series of projects in a projected 5-year program to develop U.S. activity in the groundfish resources. It calls for the Alaska Fisheries Development Foundation, a nonprofit organization representing fishermen and processors to: 1) Convert a shrimp trawler to conduct mid-water and bottom-trawling; 2) make minor modifications on a large, off-shore trawler for the same purpose; 3) demonstrate automated longline fishing techniques which can be accomplished through the adding of new equipment to some existing boats; and, 4) to train interested fishermen in the new techniques required.

The agreement is a result of the national effort launched by the Administration through NOAA and its parent agency, the Department of Commerce, earlier this year to help U.S. fishermen enter fisheries for species they do not now harvest. The program is coordinated with State of Alaska fisheries development projects, and will be monitored by the Alaska Region of the National Marine Fisheries Service.

Marine Fishery Advisory Committe Members Named

Secretary of Commerce Juanita M. Kreps has announced eight appointments to the Department's top level Marine Fisheries Advisory Committee. The Committee advises the Secretary on programs carried out by the National Oceanic and Atmospheric Administration.

Topics of concern to the Committee include international fisheries, conservation, aquaculture, biological and environmental research, fisheries technology, administration of the Marine Mammal Protection Act of 1972 and the Endangered Species Act, and fishery management issues associated with extended fisheries jurisdiction.

Members of the Committee are chosen for recognized competence and proven interest in the marine fishery resources of the United States and are appointed by the Secretary for a term of 3 years. Approximately one-third of the members are replaced each year to insure continuity on the Committee. Members are selected to provide a balanced representation by geographic area and represent a broad view of the U.S. commerical fishing industry, marine recreational fishing, the academic community, conservation interests, State governments, and the consumer.

The new appointees are: Edith H. Buss, President, Education Fund, Texas Consumer Association, Austin Tex.; Robert B. Ditton, Associate Professor of Recreation and Parks, Texas A&M University, College Station, Tex.; George J. Easley, commercial fisherman, Coos Bay, Oreg.; John S. Gottschalk, Legislative Council, International Association of Fish and Wildlife Agencies, Washington, D.C.; Thomas L. Kimball, Executive Vice President, National Wildlife Federation, Washington, D.C.; Hideto Kono, Director, Hawaii State Department of Planning and Economic Development, Honolulu, Hawaii; and Henry S. Sesepesara, Director, Marine Resources, Government of American Samoa, Pago Pago, American Samoa. Ronald Jensen, President and Chairman of the Board, Pan-American Fisheries, Inc., Seattle, Wash., has been reappointed for a second term.

Other members of the Committee are: H. Heber Bell, H. Bell & Sons, St. Petersburg, Fla.; John T. Campbell, Campbell Music Service Inc., Plymouth, Mass.; Charles H. W. Foster, Dean, School of Forestry and Environmental Studies, Yale University, New Haven, Conn.; Alan D. Guimond, Executive Secretary, Atlantic Offshore Fish & Lobster Assoc., Bristol, R.I.; Sidney E. Herndon, President, Herndon Marine Products, Inc., Aransas Pass, Tex.; Edgar J. Huizer, former Deputy Commissioner, Alaska Department of Fish and Game, Juneau, Alaska; Herbert R. Kameon, President, Pacific Region, National Coalition for Marine Conservation, Santa Monica, Calif.; William C. Lunsford, Jr., Assistant Secretary, Zapata Haynie Corp., Towson, Md.; Fred Maly, Outdoor Editor, *San Antonio Light*, San Antonio, Tex.; Edward P. Manary, Manager, Washington State Commercial Passenger Fishing Vessel Assoc., Olympia; Stephen B. Mathews, Associate Professor, College of Fisheries, University of Washington, Seattle; Ann McDuffie, Food Editor, *Tampa Tribune*, Tampa, Fla.; Kathryn E. Po-

land, State Senator, Juneau, Alaska; Haakon Ragde, Seattle, Wash.; Manuel A. Silva, former President, American Tunaboat Assoc., San Diego, Calif.; Dorothy F. Soule, Director, Harbors Environmental Project, Allan Hancock Foundation, University of Southern California, Los Angeles; Jesse L. Webb, Sales Manager, Pflueger Marine Taxidermy, Hallandale, Fla.; Lee J. Weddig, Executive Vice President, National Marine Fisheries Institute, Washington D.C.; Christopher M. Weld, attorney, Sullivan and Worcester, Boston, Mass.

Pioneer Shellfish Researcher Donates Library to NMFS Lab

Victor L. Loosanoff, a pioneer researcher in shellfish biology for half a century, has contributed his extensive personal library of scientific reprints and journals to the NMFS Southwest Fisheries Center's Tiburon Laboratory in Tiburon, Calif., Izadore Barrett, Director of the Center at La Jolla, has announced. Loosanoff, widely known for his research on shellfish aquaculture, was a Senior Scientist at the Tiburon Laboratory from 1962 to 1965, when he retired from government service.

The collection of publications which Loosanoff donated to the Tiburon Laboratory contains bound volumes of more than 10,000 reprints the majority dealing with bivalve mollusks — oysters, clams, scallops, mussels, and the like. Many of the articles describe the morphology, physiology, ecology, and propagation of shellfish. The collection also includes rare papers on bivalve diseases, predators, and parasites. Loosanoff, himself the author of more than 300 scientific articles, used the library in carrying out his extensive aquaculture and shellfish research at the Milford Laboratory on Long Island Sound.

In accepting the library for NMFS, Norman Abramson, Director of the Tiburon Laboratory, pointed out that the Loosanoff collection is unique and would by difficult to duplicate anywhere in the world.

Born in Kiev, Russia, Loosanoff received his under graduate degree from the University of Washington and his doctorate from Yale University. He entered government service as an aquatic biologist with the U.S. Fish and Wildlife Service (predecessor agency of the National Marine Fisheries Service), serving as the Director of the Marine Biology Laboratory in Milford, Conn., for 27 years.

Habitat Research Program Announced

America's only active underwater habitat is back in business off St. Croix, U.S. Virgin Islands, as "home" for scientific teams investigating the ecology of local waters. It supports regional projects seeking information about the marine environment and application to problems in U.S. continental coastal regions.

Owned and maintained by the National Oceanic and Atmospheric Administration (NOAA), the habitat—formerly known as *Hydrolab*—was recently awarded an American Bureau of Shipping Interim Class Certificate as a Class I Habitat.

The first scientific team to mount a week-long research effort from the newly classified habitat was led by John Ogden of Fairleigh Dickinson University. In early July the team built small "reefs" out of cinder block near the habitat, and observed fish settlement and colonization patterns. Such studies, it is hoped, will lead to better understanding of fish behavior and how fish communities can be established in areas that previously had few or none.

A second team from Fairleigh Dickinson is investigating how fast sediment moves down the underwater canyon to fill basins on the continental shelf. This movement affects the biology of the area and sources of sand and gravel in ways that are not yet understood. Dennis Hubbard of Fairleigh Dickinson and leader of the second mission, is with the West Indies Laboratory of the University, which operates NOAA's habitat under contract.

A University of Michigan team headed by Donald B. Macurda, Jr., and Lee Somers used NOAA's underwater laboratory in late August to investigate the feeding behavior of stationary flower-like animals called crinoids and ophiuroids, to better understand the relative importance of these animals in coral reef ecology.

Ernest H. Williams, Jr., of the University of Puerto Rico directed a team, 10-27 September, in research on parasites of various fish. The group captured fish that were infested with the parasites, others that were not, transfered the parasites, and tagged, released, and monitored the infested fish. Susceptibility or immunity of various species, and other information, was obtained. This work will be useful in learning more about how parasites spread among fish, and how environmental health affects the spread.

David B. Olson of the Island Resources Foundation, St. Thomas, V.I., led a mission in October to find out more about the growth and mortality rates of black coral in the area. Black coral has recently been used in considerable quantity by local jewelers, and the Virgin Islands Government has become concerned that the coral may be over-harvested. Olson's work will assist the local government in establishing guidelines for the coral harvest. William B. Gladfelter and William S. Johnson of the West Indies Laboratory, Fairleigh Dickinson University, also surveyed plankton-feeding fish during a late-October mission.

NOAA Studies Impact of Campeche Oil Spill

NOAA plans to commit at least an additional $700,000, and perhaps as much as $1 million, to a study assessing the present and long-term impacts of

the Campeche oil spill on the fragile coastal ecosystems of South Texas, Administrator Richard A. Frank has announced.

In making the announcement upon his return from the oil spill site and Port Isabel, Tex., Frank said the assessment and research program will be conducted in close cooperation with the Environmental Protection Agency as part of the oil spill containment effort being coordinated by the Coast Guard.

"Scientists from NOAA and other Federal, State, and local agencies have been attempting, by innovation and improvising with the latest technologies, to mitigate the effects of the oil spill through computer forecasts and modelling studies of the Gulf of Mexico currents, including satellite, aerial, and ocean surface surveillance, fisheries advisories, vulnerability studies, and the like," Frank said.

"The full scale of that effort is an outstanding improvisation of talent and technology in a dynamic, threatening, and only partially understood situation," Frank said. "Now we are undertaking a new program to determine what the effects of this record-breaking spill will have been and will be on the life and environment of the area.

"We enter this new stage because the long-term impacts of this oil spill pose serious threats to a variety of onshore and off-shore life," Frank emphasized, adding, "We are now dealing with an environmental insult on an immense scale, requiring a new dimension of study and attack."

The new study sent 100 researchers into the field to tally the impact of Mexican oil along the South Texas shoreline. While the study will focus primarily on the impact upon wildlife and environment—from bird counts and fish samplings to habitat studies and beach morphology—Frank said it will also examine the socioeconomic impacts of the spill; for example, the impact of curtailed tourism on Padre Island and the effect on the fishing industry.

In addition, Frank said, the NOAA Ship *Researcher*—one of the agency's major oceangoing research vessels—was directed from other projects to begin a systematic study along the boundaries of the slick, from the well site northward into U.S. coastal waters. The 22-day voyage of the vessel explored such uncertainties as the quantity of submerged oil, and how the oil drifting northward changed with time and distance from the well site. An accompanying tender, along with NOAA's Orion research aircraft, were expected to round out the coordinated air-sea study in and around the drifting oil, to explore the effects of the slick on interactions between the ocean and atmosphere, as well as on regional weather.

While the impact assessment and related research studies mark an important new direction in NOAA's participation in the Federal response to the Campeche spill, Frank explained that the team from NOAA and other scientific agencies will persist in its efforts to mitigate the impact of the drifting oil.

These efforts have brought some 80 of NOAA's scientists and technicians, spanning the full range of environmental science—oceanography, meteorology, fisheries biology, remote sensing, and related technologies—to a command center at Corpus Christi. At this location, NOAA is adding its expertise to the efforts of the Coast Guard, EPA, Fish and Wildlife Service, Bureau of Land Management, National Park Service, and a variety of other state and local agencies, as well as a number of private industry representatives.

Wetlands Tied To Future Fish Declines

Future decline and extinction of fish and shellfish in coastal areas may result from the loss of the essential wetlands and critical habitat, James P. Walsh, NOAA's Deputy Administrator has pointed out. Speaking at a National Workshop on Mitigating Losses of Fish and Wildlife Habitats in Fort Collins, Colo., Walsh said that the job of protecting and conserving marine and estuarine habitats is going to get tougher.

"Conflicts between protection and development continue to multiply in our coastal zones, especially conflicts over the use of dwindling wetlands," Walsh said. "The complexity of the matter, competition for scarce space in the coastal zones, pollution problems, and, unfortunately, a fair amount of public indifference and distrust of government intentions adds to our habitat protection problems."

NOAA is concentrating on habitat protection activities by the National Marine Fisheries Service and Coastal Zone Management programs to include estuarine and marine sanctuaries and pollution research efforts, Walsh said. Under the Coastal Zone Management Act and regulations, habitats of particular concern must be inventoried by the states, and procedures developed for protecting and restoring their conservation and ecological value, Walsh told the group.

"Fourteen state programs covering more than 75 percent of our Nation's coasts have been approved, and six more are slated for approval in the next several months," he said. "States with approved coastal programs are being required to devote an increasing percentage of their Federal funds for protection of natural areas. In addition, we are developing map overlays that identify coastal areas that are environmentally critical and least suitable as sites for energy facilities or other major developments."

Walsh noted that NOAA's pollution research had resulted in dramatic results. He cited a pioneering series of in-depth studies of adult striped bass in California which is possibly the first documentation of long-term chronic effects of heavy metals, PCB's, and other chlorinated hydrocarbons on mature fish. Additional studies on the east coast have shown that these pollutants can inhibit the normal growth and development of fish eggs.

New Fisheries Development Program Announced by FAO

A $35 million program for developing countries with extended fishing limits to help them benefit from their new resources has been announced by the United Nations Food and Agriculture Organization (FAO). Designed to respond to urgent requests for help from developing coastal states, the program covers every aspect of fisheries management, from the framing of basic policy to resource assessments and advice on legal, financial, and marketing questions.

Kenneth C. Lucas, Assistant Director-General of FAO's Fisheries Department, said it was the view of the Director-General that the consensus on 200-mile economic zones reached at the UN Law of the Sea Conference in New York gave developing coastal states an unprecedented opportunity to build up their fisheries as a valuable food source for domestic use and for export and to take a greater share of the total world catch of over 70 million tons a year.

"If all coastal states declare 200-mile zones, an area almost equal to the earth's land surface will come under national jurisdiction for the first time. Without efficient management, these zones could become the setting for the same tragedies of overfishing and economic collapse that occurred in some coastal areas before the extension of coastal state jurisdiction. We now have a definite but shortlived opportunity to build a base for stable fisheries development," he said.

Lucas said the FAO program will include both medium and long-term measures. The Organization will give immediate priority to assessing fisheries development opportunities and to comprehensive analyses of policy problems throughout the world. Work in this field is already under way in Malaysia, West Africa, the Philippines, and Seychelles.

Over the longer term FAO will provide specialized advisory and technical assistance to help nations assess their fisheries resources and the best use that can be made of them. Assistance of this type has already been offered to Burma, Sierra Leone, Guinea, Indonesia, Malaysia, Thailand, and the Philippines.

The Organization will also be supplying expert advice, again on request, concerning legislation in management of fisheries.

Lucas said FAO, with 30 years of experience in fisheries management and development throughout the world, was in a unique position and had a special mandate to conduct programs of this type. The Organization already has well-established regional programs in the South China Sea, the West African Coast, the Indian Ocean, and West Central Atlantic.

He explained that fish now accounts for roughly 55 percent of the animal protein consumed in Asia and 24 percent in Africa. By the year 2000 demand for fish could well double with more than three-quarters of the increase coming from developing nations.

Fisheries development will also bring economic benefits with better incomes and employment opportunities for some 10 million fishermen and 40 million shore workers presently employed in developing countries, he said. A strengthening of the fishing industry will also benefit foreign exchange balances for many developing countries.

The FAO program will cover the following areas: 1) Specialized help in framing policies and strategies for the management and development of fisheries zones; 2) assistance in stock assessment so that coastal states can set catch quotas and adopt other management measures; 3) strengthening regional fisheries bodies, particularly those established through FAO, to enable them to respond effectively to the new situation created by the proliferation of 200-mile zones; 4) promoting sound investment in fisheries development by national and international institutions (FAO estimates that at least $30 billion will be needed by the end of the century); 5) technical support for extended economic zone management and development; 6) assistance in legal and institutional aspects of economic zone management and surveillance; and 7) assistance in distributing and marketing fish products.

Australia Experiments With Blue Grenadier

Large quantities of the deepwater blue grenadier, *Macruronus novae sealandiae*, were landed in South Australia during January 1979 to an enthusiastic reception by processors according to a report in *Australian Fisheries*. The stern trawler *Margaret Phillipa* landed some 200 metric tons (t) of this previously little-exploited species in the second half of January from grounds off the west coast of Tasmania.

The Australian General Manager of the South Australian Fishermen's Cooperative Limited (SAFCOL), Mal Pach, said development of the blue grenadier fishery would prove an important step towards Australian self-sufficiency in fish. He predicted development of the blue grenadier fishery would be more important than the gemfish fishery. Blue grenadier would provide economical fresh, frozen, and smoked fish for consumers. It would cost less than gemfish, which had developed a large market in South Australia as a low-price, high-quality fish.

The first major landing of blue grenadier was 42 t. About 6 t was sold on

the fresh fish market and the remainder sent to SAFCOL's fish processing plant at Millicent for production of smoked fish and frozen fillets. Blue grenadier also was to be tested for use in production of fish fingers from the Millicent plant, expected to begin in early 1980.

Pach said the blue grenadier was first discovered in waters off the South Island of New Zealand, where it is known as whiptail. The fish caught by the *Margaret Phillipa* had been taken from waters as deep as 800 m. The fish were about 1 m long, weighed 4-5 kg, and produced fillets with soft, delicate texture.

Australian Fisheries also reported that the trawler *Zeehaan* made further good catches during a continuing deep water survey off the Tasmanian west coast. The government-chartered vessel made the catches in January on grounds between King Island and Strahan from which it also took good hauls of these species early last year.

The deep water trawling survey was sponsored jointly by the Commonwealth Government and the Tasmanian Fisheries Development Authority (TFDA), with staff from the Commonwealth Department of Primary Industry's Fisheries Division and the TFDA on board *Zeehaan* during the surveys.

The phase of the survey beginning January included surface and deepwater temperature probes, water sampling, fish length frequency measurements, and otolith sampling designed to aid assessment of fish stocks in the area and their schooling behavior. Information is processed by the CSIRO Division of Fisheries and Oceanography in Sydney.

Japan Outlines Fishery Problems

Japan's Fisheries White Paper for fiscal year 1978 (1 April 1978-30 March 1979) points out that the Japanese fisheries catch was maintained at an adequately high level in 1977 and 1978, with increases in coastal and offshore catches largely offsetting decreases in the catch made in foreign 200-mile fishing zones. In a departure from previous White Papers, however, it focused on a number of problems facing Japan's fisheries.

The problems identified included: 1) The need to reassess and better conserve and manage Japan's offshore and coastal fishery stocks, and to stabilize fishery prices; 2) the need to improve conditions in remote Japanese fishing communities which are losing population; 3) the need to improve diplomatic efforts aimed at gaining additional or greater access to the 200-mile fishing zones of other nations; and 4) the need for greater efforts in artificial salmon hatching, conservation of tuna resources, and prevention of coastal pollution.

The White Paper presents detailed statistical data on Japan's fisheries in 1977. The most important developments were given for catch, consumption, fishing companies and fishermen, and trade.

Catch

Japan's 1977 fisheries catch totaled 10.8 million metric tons (t), a slight increase over the 1976 catch of 10.7 million t. Japan is the world's most important fishing nation, and its catch was nearly 15 percent of the world's total fisheries catch in 1977. The composition of the 1977 Japanese catch showed that offshore and coastal catches totaled 7.9 million t, up 5.8 percent and 4.1 percent, respectively, over 1976, while distant water catches totaled 2.7 million t, a decrease of 9.7 percent below that of 1976. The most significant developments were record coastal catches of sardine and mackerel and a sharp decline in the Alaska pollock catch.

Consumption

Per capita consumption of fishery products, reflecting consumer resistance to increased fish prices in 1976-77, decreased to 47.4 percent of total animal protein intake in 1977, continuing a trend in Japan of greater meat and other nonfish protein consumption relative to fish.

Fishing Companies and Fishermen

The total number of marine fishing establishments in Japan in 1977 was 212,000[1], a 0.3 percent decline from 1976. The total number of fishermen in 1977 was 459,000 (of whom 360,000 were coastal fishermen), a slight decrease from 1976.

Trade

Japan's 1977 fishery imports totaled 1.1 million t valued at 6.6 billion yen (US $2.4 billion), an increase of 28 percent in quantity and 17 percent in value over 1976. Japan's 1977 fishery exports totaled 590,000 t valued at 1.8 billion yen (US $686 million), a decrease of 9 percent in quantity and 17 percent in value from 1976. The negative balance of fisheries trade thus exceeded US $1.7 billion. (Source: IFR-79/96.)

Ural River Fisheries Increases Predicted

More than 10 million kg of sturgeons and salmonids and 1 million kg of black caviar are taken from the Russia's Ural River annually, a sum that is from 40 to 50 times more than was harvested there 30 years ago, according to Soviet scientists. The Ural River, 1,575 miles long, is about 300 miles longer than the Columbia River and empties into the Caspian Sea. It is also predicted that new biological and technical regimes could increase the river's productivity and fish catch almost fourfold by the year 2000.

On the recommendation of Russian ichthyologists, the traditional Ural River fishery has been changed to the mouth of the river and fishing operations are conducted on a "3 days on, 2 days off" schedule. Under this system, catches are predicted to increase with out significantly affecting spawning fish. (Source: LSD 79-11.)

[1]Many of these establishments are small associations of as few as two or three fishermen.

The Fisheries of Cape Verde

The Government of Cape Verde is placing great hopes on its fishing industry and expects over the next 10 years to invest $93 million in that sector. Despite these rather ambitious plans, the development of Cape Verde's fishing industry faces many obstacles, according to the NMFS Foreign Fisheries Analysis Division.

Background

The Government of Cape Verde has repeatedly stated that the fishing and tourist industries are two areas in which Cape Verde has considerable potential. Faced with a burgeoning population of 327,000 growing at an annual rate of 2.9 percent, a continuing deficit in food production (in 1979, Cape Verde was expected to import at least 75 percent of its food), and with no mineral resources yet discovered on the Islands, Cape Verde hopes that its fisheries can be developed to reduce the quantity of food which must be imported. It is also hoped that fishery exports will earn additional and badly-needed foreign exchange.

Fishing Industry

Cape Verde's fishing industry is neither well developed nor extensive. The waters around the islands are rough and during a good part of the year high winds and high waves make fishing hazardous. Throughout the islands there are about 800 fishing vessels, or "botes[1]," 5-8 m long, with crews of two or three. The botes are planked sailboats made locally, mainly on the islands of Brava and Sao Vicente (Fig. 1) from imported wood (which costs at least three times as much as it does in the United States).

In January 1978, at a small shop in Mindelo on Sao Vicente Island, production of fiberglass vessels began. However, because of their prohibitive cost, few have been sold. In 1978 about 50 percent of the 800 Cape Verde fishing vessels were based on Santiago Island, with another 30 percent working off Sao Vicente. The Cape Verde fishing fleet now has fewer vessels than in recent years, probably because some were owned by the Portuguese who returned to their home country when Cape Verde became independent in 1975.

Fisheries

The Government of Cape Verde declared a 200-mile Exclusive Economic Zone (EEZ) in early 1978. The EEZ covers an area of about 200,000 km² including 3,500 km² of continental shelf. About 3,000 fishermen operate along the 1,000-km coastline. Their catch amounts to about 6,350 metric tons (t) annually (5,350 t pelagic species, 900 t demersal and tuna species, and 100 t crustaceans), with a value of about 120 million escudos a year (US$3.2 million)[2].

The waters of Cape Verde contain moderate quantities of horse mackerel, whitefish, barracuda, grouper, tuna (various species), and occasionally whales, as well as some lobsters. Like many tropical countries, the waters of the archipelago do not contain abundant stocks of fish and shellfish. During portions of the year, fish is not available in the domestic markets of Cape Verde and the variety of species available is always limited. A Cape Verde fisheries expert estimates that the country's fisheries catch could increase, from a total of little more than 6,000 t, to 17,000 t a year by modernizing the fleet and improving storage capabilities.

The waters of Cape Verde do have substantial, though migratory, stocks of bigeye, bluefin, yellowfin, and skipjack tuna. Tuna fishing takes place from July to October. Cape Verde concluded an agreement with Angola in October 1978 permitting six Cape Verde tuna vessels to fish in Angolan waters during the off-season. Fifty percent of Cape Verde's catch in Angolan waters, however, must be landed in Angolan ports.

Processing Facilities

In early 1978, six canning plants were operating on Santiago, Boa Vista, Sal, Sao Nicolau (2 plants), and Maio Islands, employing about 540

[1]Botes is the word for vessels in Orioulo, the local language.

[2]One ton of landings would thus average about US$450.

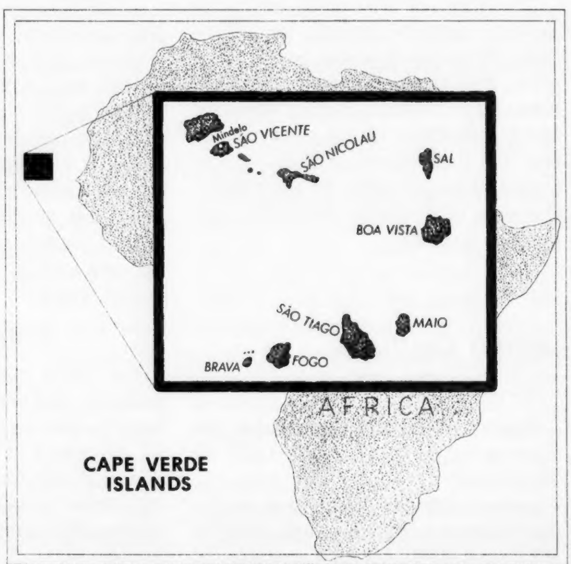

Figure 1.—Cape Verde Islands.

people (mostly women) during the tuna season. The six plants are now operating at about 55 percent of capacity because landings have declined since the Portuguese left. These plants are owned by firms operating 15 small vessels (up to 20-23 m long) and three large vessels (up to 30 m long). These vessels normally fish within 30 miles of the coast. The total production of canned fish is about 560 t per year[3]. A large part of the production of canned tuna (packed in 2-kg cans with water mixed with cooking oil) is exported to the United States and Portugal. These plants have recently faced two continuing problems: 1) An inadequate supply of tuna, and 2) nonavailability of oil to preserve the canned product.

At Mindelo, on the island of Sao Vicente, there are two companies with cold storage and freezing plants. FRICAPE, the largest, has a present cold storage capacity of 3,000 tons and has based its operation on a tuna fleet of 10 wooden pole-and-line vessels and 3 steel tuna purse seiners. Their average monthly catch during 1975-77 varied from 20 to 150 t per month.

FRICAPE was negotiating earlier in 1979 with a U.S. tuna company for the lease or purchase of a tuna seiner with a carrying capacity of 900 t. The Cape Verde Government was pleased with the proposed contract and was interested in negotiating the purchase by that company of chilled and frozen tuna. The vessels presently owned by FRICAPE have an on-board total freezing capacity of only 200 t.

The second freezing enterprise is Frigorifico Exporters; it has a cold storage capacity of 300 tons and presently operates three tuna vessels. The Government of Cape Verde has decided that it will not encourage the expansion of Frigorifico Exporters. Instead, the Government will actively support the expansion and development of FRICAPE, which until independence was operated as CONGEL under the joint Portuguese-Cape Verde ownership.

[3]In February 1978, the canned products were sold at an average price of US$1,950 per ton on world markets.

Development Plans

The Government of Cape Verde planned to expand the cold storage facilities at Mindelo to 9,000 t during 1979. The Government of the Netherlands, through the Dutch firm ARENCO and with financing in the amount of 6.5 million florins ($3 million), has assisted in this effort. As part of this project, modern wharves were constructed in Mindelo; vessels requiring a draft of up to 7 m will be able to come alongside the new piers. The Cape Verde Government also plans to establish a fish filleting operation at Mindelo and will be looking for financing in the amount of US $4 million for this project. The Government hopes that this operation will be producing 6,000 t of fillets per year by the end of 1982. The Government also plans to build a fish net factory at Mindelo and again will be looking for financial assistance for this project.

Though funding is an obvious problem, the Government of Cape Verde has rather ambitious plans to increase the country's present highseas fishing fleet by a total of 19 vessels, including 12 purse seiners, 5 stern trawlers, and 2 refrigerated fish carriers. The Embassy estimates that the cost of these vessels would amount to at least U.S. $80 million.

Lobster Exports

The Government of Cape Verde plans not only to increase its annual catch of fish, mostly tuna and horse mackeral, but also hopes to increase the annual per capita consumption from the present 13-15 kg to 20 kg by the end of 1980. It does not appear likely that this goal will be attained mainly because of the lack of cold storage facilities, expecially on the two most populous islands, Fogo and Santiago. In the interior of Santiago Island fish is rarely available, and then only in dried form.

Lobster is caught for export on the islands of Sal and Maio. The total lobster catch of all the islands of the archipelago is about 110 t per year. A large part of this catch is air-freighted from the Sal Airport to Portugal, France, and the United States. On Sal Island, a plant with holding tanks for live fish and freezing units is partially finished. Approximately $2 million would be required to finance the completion of this facility, which was abandoned at the time of independence. A lobster export operation could be begun on Brava and Fogo Islands. Lobster stocks could be commercially harvested on these islands and catches from Sal Island could be increased. Lobsters sell at a low price (US$1.00/kg on Brava, US$2.50/kg on Fogo, and US$3.50/kg on Sal). The Government of Cape Verde estimates that an additional 100 t of export-quality lobster stocks could be harvested each year without causing any damage to the lobster stocks. There are direct air connections from Sal Island to New York (thrice weekly); Lisbon (twice weekly); and Paris, London, Frankfurt, and Amsterdam (once a week).

Investment

From the 1978 budget the Cape Verde Government plans to invest a total of 130 million Cape Verde escudos in the fishing sector (approximately $4 million). Of this total, 50 million escudos ($1.5 million) will be spent on development and expansion of the freezing plant at Mindelo and the remaining 80 million escudos ($2.5 million) will be used to modernize artisanal fisheries. The latter will include financing the purchase of outboard motors for small fishing boats. During the next 10 years, the of Cape Verde expects to invest a total of $93 million in fisheries.

Foreign Aid

The Government of Japan has also shown some interest in financing artisanal fishing projects, perhaps in exchange for using Mindelo as a base for one of its fishing fleets, a situation which existed prior to independence. For the present, at least, it appears as though Cape Verde will continue to deny rights to fish in its 200-mile fishing zone to any of the major powers. (Source IFR-79/89.)

Fisheries Management and Predator-Prey Systems

"Predator-Prey Systems in Fisheries Management", edited by Henry Clepper and published by the Sport Fishing Institute, presents the proceedings of the First International Symposium on Predator-Prey Systems in Fish Communities and Their Role in Fisheries Management held in July 1978 in Atlanta, Ga.

The 40 chapters are contained in eight sections (meeting sessions) with floor discussions at the end of each. The introductory session focused on fisheries management and the global future with an overview of predator-prey relations in fishes. The second session, "Influence of abiotic variables on predator-prey structure," deals with an "optimal" environment and with the effects of weather, climate, and physical and chemical alterations on fisheries and predator-prey dynamics. Session III, "Influence of predators on structure of aquatic ecosystems," is divided into three parts: Marine ecosystems, lake and pond ecosystems, and stream and river ecosystems. Marine ecosystem chapters deal with multilevel system effects of predation, predator-prey interactions in the eastern Bering Sea and in estuarine areas, and predation's role in structuring reef fish communities.

Contributions to "Patterns of predation," Session IV, include optimal foraging in fish, food selection by plankton feeding fishes, prey selection by benthic feeders, interactions between piscivorous fishes and their prey, predation patterns in generalist feeders and in simple and complex environments, relationships between habitat and feeding mechanisms in fishes, and predator-prey models for fisheries management.

Session V, "Competition, diversity, and food supply," contains contributions on resource partitioning, niche partitioning by food size, habitat partitioning and competition, factors that influence the abundance of large piscivorous fish, and behavioral response of prey to fish predators.

"Potential management strategies," Session VI, includes use of predator-prey relationships in fisheries management, managing pelagic schooling prey species, management to increase anadromous salmon production, food consumed by continental shelf fishes, natural lake fish management strategy, controlling predator-prey relationships in streams, and predator-prey systems in large reservoirs. Final chapters, Session VII, examine predator-prey relationships in management of small impoundments, trophic dynamics of a freshwater artificial tire reef, and predator-prey dynamics among walleye and bluegill. Session VIII presents a summary of the symposium.

Copies of the book may be purchased from the Sport Fishing Institute, 608 13th St., N.W., Suite 801, Washington, DC 20005. The price is $20, postpaid ($23 outside the United States) and air parcel postage is additional. Payment must accompany each order.

Marine Ecology Now A Quarterly Journal

Marine Ecology - Progress Series, edited by O. Kinne of the Biologische Anstalt Helgoland in Hamburg, Germany, has been started as a quarterly journal to succeed the book series entitled "Marine Ecology - A Comprehensive, Integrated Treatise on Life in Oceans and Coastal Waters." The new journal publishes both original papers and reviews in five general areas: Environmental factors, physiological mechanisms, cultivation, dynamics, and ocean management. Price per volume (four issues) is listed as 195 DM. For ordering information, contact Inter-Research, P.O. Box 1121, 2083 Halstenbek, Federal Republic of Germany.

NMFS TECHNICAL REPORTS AVAILABLE

NOAA Technical Report NMFS SSRF-729. Dowds, Richard E. "**References for the identification of marine invertebrates on the southern Atlantic coast of the United States.**" April 1979. 37 p.

ABSTRACT

This collection of 638 citations provides an entry to the taxonomic literature on invertebrates of the continental shelf and estuaries from the Chesapeake Bay to northeastern Florida. Many of the citations are annotated and most include a list of North Carolina libraries in which they can be found. Author and systematic indices are provided.

NOAA Technical Report NMFS SSRF-731. Hoff, James G. **"Annotated bibliography and subject index on the shortnose sturgeon, *Acipenser brevirostrum*."** April 1979. 16 p. For sale by the Superindentent of Documents, U.S. Government Printing Office, Washington, DC 20402.

ABSTRACT

This bibliography consists of 165 references on the classification, distribution, abundance, life history, and ecology of the shortnose sturgeon, *Acipenser brevirostrum*. Brief annotations and a subject index are included for this rare and endangered species.

Editorial Guidelines for *Marine Fisheries Review*

Marine Fisheries Review publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 6, "A List of Common and Scientific Names of Fishes from the United States and Canada," third edition, 1970. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

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Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

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Title the list of references "Literature Citations" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, the year and month and volume and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

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Authors must double-check all literature cited; they alone are responsible for its accuracy.

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All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8- × 10- inches, sharply focused glossies of strong contrast. Potential cover photos are welcome but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

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Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 1107 N.E. 45th Street, Room 450, Seattle, WA 98105.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 100 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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